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[*Frontispiece*, *Vol. xxix.*]

JAMES STEDMAN DIXON,

PRESIDENT OF THE INSTITUTION OF MINING ENGINEERS, 1901-1902.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

VOL. XXIX.—1904-1905.

EDITED BY M. WALTON BROWN, SECRETARY.

NEWCASTLE-UPON-TYNE: PUBLISHED BY THE INSTITUTION.

PRINTED BY ANDREW REID & Co., LIMITED, NEWCASTLE-UPON-TYNE.
1906.

ADVERTIZEMENT.

The Institution, as a body, is not responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at the meetings of the Institution or of the Federated Institutes.

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THE INSTITUTION OF MINING ENGINEERS.

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* Deceased.

Mr. William Nicholas Atkinson, H.M. Inspector of Mines, Bridgend.
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President.

* Deceased.

*Sir LOWTHIAN BELL, Bart., Rounton Grange, Northallerton.

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Mr. Robert Summerside Williamson, Cannock Wood House, Hednesford, S.O., Staffordshire.

Councillors.

* Deceased.

Mr. Frederick Robert Atkinson, Duffield, Derby.
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Mr. George Jonathan Binns, Duffield House, Duffield, Derby.
Mr. Bennett Hooper Brough, 28, Victoria Street, London, S.W.
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Mr. Reginald Guthrie, Neville Hall, Newcastle-upon-Tyne.
Mr. James Hamilton, 208, St. Vincent Street, Glasgow.
Mr. Arthur Hassam, King Street, Newcastle, Staffordshire.
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Mr. Thomas Edgar Jobling, Bebside, S.O., Northumberland.
Mr.* Philip Kirkup, Leafield House, Birtley, S.O., County Durham.
Mr. Charles Catterall Leach, Seghill Colliery, Seghill, Dudley, S.O., Northumberland.
Mr. George Alfred Lewis, Albert Sreet, Derby.
*Mr. William Logan, Langley Park, Durham.
Mr. Henry Louis, 4, Osborne Terrace, Newcastle-upon-Tyne.
Mr. Henry William Martin, Sherwood, Newport Road, Cardiff.
Mr. George May, The Harton Collieries, South Shields.
Mr. George Arthur Mitcheson, Market Place, Longton, Staffordshire.
Mr John Morison, Cramlington House, Northumberland.
Mr. David Marr Mowat, Summerlee Iron Works, Coatbridge.
Mr. Robert Douglas Munro, 111, Union Street, Glasgow.
Mr. John Nevin, Littlemoor House, Mirfield, S.O., Yorkshire.
Mr. Lucius Trant O'Shea, University of Sheffield, St. George's Square, Sheffield.
Mr. Henry Palmer, Medomsley, S.O., County Durham.
Mr. Matthew William Parrington, Wearmouth Colliery, Sunderland.
Mr. William Henry Pickering, 6, Dacres Lane, Calcutta, India.
Mr. Henry Richardson, 89, Ashley Gardens, Westminster, London, S.W.
Mr. William Saint, Queen's Chambers, 5, John Dalton Street, Manchester.
Mr. Arthur Robert Sawyer, P.O. Box 2202, Johannesburg, Transvaal.
Mr. Frank Robert Simpson, Hedgefield House, Blaydon-upon-Tyne, S.O., County Durham.
Mr. John Simpson, Heworth Colliery, Felling, S.O., County Durham.
Mr. Alexander Smith, 3, Newhall Street, Birmingham.
*Mr. Charles Sebastian Smith, Shipley Collieries, Derby.
Mr. Sydney Arthur Smith, 1, Princess Street, Albert Square, Manchester.
Mr. Thomas Thomson, Fairview, Hamilton.
Mr. John Thomas Todd, Blackwell Collieries, Alfreton.
Mr. Thomas Turner, Caledonia Works, Kilmarnock.
Mr. John Robert Robinson Wilson, H.M. Inspector of Mines, West Hill, Chapeltown Road, Leeds.
Mr. Robert Winstanley, 42, Deansgate, Manchester.
Mr. William Outterson Wood, South Hetton, S.O., County Durham.

Auditors.

Messrs. John G. Benson and Son, Newcastle-upon-Tyne.

Treasurers.

Messrs. Lambton and Company, The Bank, Newcastle-upon-Tyne

Secretary.

Mr. Martin Walton Brown, Neville Hall, Newcastle-upon-Tyne.

THE INSTITUTION OF MINING ENGINEERS.

FOUNDED JULY 1ST, 1889.

BYE-LAWS.

As revised at Council Meeting held on September 13th, 1905.

I.—CONSTITUTION.

1.—The Institution of Mining Engineers shall consist of all or any of the societies interested in the advancement of mining, metallurgy, engineering and their allied industries, who shall from time to time join together and adhere to the bye-laws.

2.—The Institution shall have for its objects—

(a) The advancement and encouragement of the sciences of mining, metallurgy, engineering, and their allied industries.

(b) The interchange of opinions, by the reading of communications from members and others, and by discussions at general meetings, upon improvements in mining, metallurgy, engineering, and their allied industries.

(c) The publication of original communications, discussions, and other papers connected with the objects of the Institution.

(d) The purchase and disposal of real and personal property for such objects.

(e) The performance of all things connected with or leading to the purpose of such objects.

3.—The offices of the Institution shall be in Newcastle-upon-Tyne, or such other place as shall be from time to time determined by resolution of the Council.

4.—The year of the Institution shall end on July 31st in every year.

5.—The affairs and business of the Institution shall be managed and controlled by the Council.

II.—MEMBERSHIP.

6.—The original adherents or founders are as follows:—

(a) Chesterfield and Midland Counties Institution of Engineers, Chesterfield.

(b) Midland Institute of Mining, Civil and Mechanical Engineers, Barnsley.

(c) North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.

(d) South Staffordshire and East Worcestershire Institute of Mining Engineers, Birmingham.

7.—Written applications from societies to enter the Institution shall be made to the Council, by the President of the applying society, who shall furnish any information that may be desired by the Council.

8.—A.—If desired by the Council, any of the Federated Institutes shall revise their bye-laws, in order that their members shall consist of Ordinary Members, Associate Members, and Honorary Members, with Associates and Students, and section B following shall be a model bye-law to be adopted by any society when so desired by the Council.

B.—"The members shall consist of Ordinary Members, Associate Members and Honorary Members, with Associates and Students:—

(*a*) Each Ordinary Member shall be more than twenty-three years of age, have been regularly educated as a mining, metallurgical, or mechanical engineer, or in some other branch of engineering, according to the usual routine of pupilage, and have had subsequent employment for at least two years in some responsible situation as an engineer; or if he has not undergone the usual routine of pupilage, he must have been employed or have practised as an engineer for at least five years.

(*b*) Each Associate Member shall be a person connected with or interested in mining, metallurgy, or engineering, and not practising as a mining, metallurgical, or mechanical engineer, or some other branch of engineering.

(*c*) Each Honorary Member shall be a person who has distinguished himself by his literary or scientific attainments, or who may have made important communications to any of the Federated Institutes.

(*d*) Associates shall be persons acting as under-viewers, under-managers, or in other subordinate positions in mines or metallurgical works, or employed in analogous positions in other branches of engineering.

(*e*) Students shall be persons who are qualifying themselves for the profession of mining, metallurgical, or mechanical engineering, or other branch of engineering, and such persons may continue Students until they attain the age of twenty-five years."

9.—The Ordinary Members, Associate Members and Honorary Members, Associates and Students shall have notice of, and the privilege of attending, the ordinary and annual general meetings, and shall receive all publications of the Institution. They may also have access to, and take part in, the general meetings of any of the Federated Institutes.

10.—The members of any Federated Institute, whose payments to the Institution are in arrear, shall not receive the publications and other privileges of the Institution.

11.—After explanations have been asked by the President from any Federated Institute, whose payments are in arrear, and have not been paid within one month after written application by the Secretary, the Council may decide upon its suspension or expulsion from the Institution; but such suspension or expulsion shall only be decided at a meeting attended by at least two-thirds of the members of the Council by a majority of three-fourths of the members present.

III.—Subscriptions.

12.—Each of the Federated Institutes shall pay fifteen shillings per annum for each Ordinary Member, Associate Member, Honorary Member, Associate and Student, or such other sum, and in such instalment or instalments as may be determined from time to time by resolution or resolutions of the Council. Persons joining any of the Federated Institutes during the financial year of the Institution shall be entitled to all publications issued for that year, after his election is notified to the Secretary, and the instalment or instalments due on his behalf have been paid.

IV.—Election of Officers and Council.

13.—The officers of the Institution, other than the Secretary and Treasurer, shall consist of Councillors elected annually prior to August in each year, by and out of the Ordinary Members and Associate Members of each Federated Institute, in the proportion of one Councillor per forty Ordinary Members or Associate Members thereof; of Vice-Presidents elected by and from the Council at their first meeting in each year on behalf of each Institute, in the proportion of one Vice-President per two hundred Ordinary Members or Associate Members thereof; and of a President elected by and from the Council at their first meeting in each year; who, with the Local Secretaries of each Federated Institute and the Secretary and Treasurer, shall form the Council. All Presidents on retiring from that office shall be *ex-officio* Vice-Presidents so long as they continue Ordinary Members or Associate Members of any of the Federated Institutes.

14.—In case of the decease, expulsion, or resignation of any officer or officers, the Council may, if they deem it requisite, fill up the vacant office or offices at their next meeting.

V.—Duties of Officers and Council.

15.—The Council shall represent the Institution and shall act in its name, and shall make such calls upon the Federated Institutes as they may deem necessary, and shall transact all business and examine accounts, authorise payments and may invest or use the funds in such manner as they may from time to time think fit, in accordance with the objects and bye-laws of the Institution.

16.—The Council shall decide the question of the admission of any society, and may decree the suspension or expulsion of any Federated Institute for non-payment of subscriptions.

17.—The Council shall decide upon the publication of any communications.

18.—There shall be three ordinary meetings of the Council in each year, on the same day as, but prior to, the ordinary or annual general meetings of the members.

19.—A special meeting of the Council shall be called whenever the President may think fit, or upon a requisition to the Secretary signed by ten or more of its members, or by the President of any of the Federated Institutes. The business transacted at a special meeting of the Council shall be confined to that specified in the notice convening it.

20.—The meetings of the Council shall be called by circular letter, issued to all the members at least seven days previously, accompanied by an agenda-paper, stating the nature of the business to be transacted.

21.—The order in which business shall be taken at the ordinary and annual general meetings may be, from time to time, decided by the Council.

22.—The Council may communicate with the Government in cases of contemplated or existing legislation, of a character affecting the interests of mining, metallurgy, engineering, or their allied industries.

23.—The Council may appoint Committees, consisting of members of the Institution, for the purpose of transacting any particular business, or of investigating any specific subject connected with the objects of the Institution.

24.—A Committee shall not have power or control over the funds of the Institution, beyond the amount voted for its use by the Council.

25.—Committees shall report to the Council, who shall act thereon and make use thereof as they may elect.

26.—The President shall take the chair at all meetings of the Institution, the Council, and Committees at which he may be present.

27.—In the absence of the President, it shall be the duty of the senior Vice-President present to preside at the meetings of the Institution. In case of the absence of the President and of all the Vice-Presidents, the meeting may elect any member of Council, or in case of their absence any Ordinary Member or Associate Member to take the chair at the meeting.

28.—At meetings of the Council six shall be a quorum.

29.—Every question shall be decided at the meetings of the Council by the votes of the majority of the members present. In case of equal voting, the President, or other member presiding in his absence, shall have a casting vote. Upon the request of two members, the vote upon any question shall be by ballot.

30.—The Secretary shall be appointed by and shall act under the direction and control of the Council. The duties and salary of the Secretary shall be fixed and varied from time to time at the will of the Council.

31.—The Secretary shall summon and attend all meetings of the Council, and the ordinary and annual general meetings of the Institution, and shall record the proceedings in the minute book. He shall direct the administrative and scientific publications of the Institution. He shall have charge of and conduct all correspondence relative to the business and proceedings of the Institution, and of all committees where necessary, and shall prepare and issue all circulars to the members.

32.—One and the same person may hold the office of Secretary and Treasurer.

33.—The Treasurer shall be appointed annually by the Council at their first meeting in each year. The income of the Institution shall be received by him, and shall be paid into Messrs. Lambton & Co.'s bank at Newcastle-upon-Tyne, or such other bank as may be determined from time to time by the Council.

34.—The Treasurer shall make all payments on behalf of the Institution, by cheques signed by two members of Council, the Treasurer and the Secretary, after payments have been sanctioned by Council.

35.—The surplus funds may, after resolution of the Council, be invested in Government securities, in railway and other debenture shares such as are allowed for investment by trustees, in the purchase of land, or in the purchase, erection, alteration, or furnishing of buildings for the use of the Institution. All investments shall be made in the names of Trustees appointed by the Council.

36.—The accounts of the Treasurer and the financial statement of the Council shall be audited and examined by a chartered accountant, appointed by the Council at their first meeting in each year. The accountant's charges shall be paid out of the funds of the Institution.

37.—The minutes of the Council's proceedings shall at all times be open to the inspection of the Ordinary Members and Associate Members.

VI.—General Meetings.

38.—An ordinary general meeting shall be held in February, May and September, unless otherwise determined by the Council; and the ordinary general meeting in the month of September shall be the annual general meeting at which a report of the proceedings, and an abstract of the accounts of the previous year ending July 31st, shall be presented by the Council. The ordinary general meeting in the month of May shall be held in London, at which the President may deliver an address.

39.—Invitations may be sent by the Secretary to any person whose presence at discussions shall be thought desirable by the Council, and persons so invited shall be permitted to read papers and take part in the proceedings and discussions.

40.—Discussion may be invited on any paper published by the Institution, at meetings of any of the Federated Institutes, at which the writer of the paper may be invited to attend. Such discussion, however, shall in all cases be submitted to the writer of the paper before publication, and he may append a reply at the end of the discussion.

VII.—Publications.

41.—The publications of the Institution shall consist of the reports of the meetings of the Institution and of the meetings of the Federated Institutes, and abstracts of patents and other publications relating to mining, metallurgy and allied industries.

The reports of the meetings shall consist of addresses, papers, and the discussions thereon.

The publications may include:—

(a) Papers upon the working of mines, metallurgy, applied geology, engineering, railways and the various allied industries.
(b) Papers on the management of industrial operations.
(c) Abstracts of colonial and foreign papers upon similar subjects.
(d) Abstracts of patents relating to mining and metallurgy.
(e) Notes of questions of law concerning mines, manufactures, railways, etc.

The following shall be deemed unsuitable, and shall be refused:—

(a) Papers containing what is in fact advertising matter.
(b) Papers consisting largely of matter already printed in the English language.
(c) Papers consisting largely of matter foreign to the objects of the Institution or Federated Institutes.
(d) Papers containing matter the publication of which may be deemed injurious to the interests of the Institution or of any Federated Institute.
(e) Papers containing matter either libellous or slanderous, or gross misstatements.

42.—The Secretary of the Institution shall be responsible for the editing of the volumes as a whole, for the editing of the reports of the meetings of the Institution and of the Federated Institutes, and for the miscellaneous portion. The Local Secretary of each Federated Institute shall prepare and edit all papers and discussions of such Institute, and promptly forward them to the Secretary, who shall submit proofs to the Local Secretary before publication.

43.—The Council shall appoint a Publications Committee to deal with questions concerning the publications.

44.—A paper for reading at any of the meetings of the Institution shall be sent to the Secretary a clear three weeks before the meeting in question. The Secretary may refer a paper back to the author for compression or alteration, or, in case the matter be deemed suitable, but objection be taken to the mode of expression thereof, he may refer it back to the author for amendment in this respect. If the Author and Secretary cannot agree as to the suitability of the paper, the Secretary shall submit it to two members of the Publications Committee. If both of these approve or reject it, their decision shall be final, but if their views differ it shall be referred to the President of the Institution, whose decision shall be final.

A paper that has been submitted to and approved by the Council of a Federated Institute shall be sent to the Secretary of the Insitution a clear fortnight before the date of the meeting at which it is intended to be read, together with any drawings or illustrations which may be required to accompany it. If desired by the Secretary of the Federated Institute, the Secretary of the Institution will then have the paper printed in galley-form for distribution at the meeting. After the meeting, the paper, revised if necessary by the Secretary in question, shall be returned to the Secretary of the Institution in its final form ready for setting up in pages. If the Secretary of the Institution, at any time, considers the paper unsuitable for appearance in the *Transactions*, he shall notify the Secretary of the Federated Institute, and shall refer it to two members of the Institution Publications Committee, excluding the Secretary or member representing the Institute from which the paper proceeds. If, in the unanimous opinion of these members, the paper is unsuitable for appearance in the *Transactions*, it shall not appear in the *Transactions*, but if their views differ, it shall be referred to the President of the Institution, whose decision shall be final.

45.—Any discussion taking place at any meetings of the Institution shall be reported by a competent reporter. The proof of each speaker's remarks in the discussion shall be sent out to him by the Secretary of the Institution with an intimation that, if not returned corrected within seven days, it will be considered as correct, and the Secretary shall then edit the revised discussion.

The Federated Institutes shall make their own arrangements for reporting the discussions at their meetings and for the correction of the reports of the speakers. The Secretary of each Federated Institute shall forward a clear transcript of the discussion, edited by him, to the Secretary of the Institution for printing. Two galley proofs, together with the manuscript, shall be sent to the Secretary of the Federated Institute for correction, one of which, together with the manuscript, shall be returned ready for printing within seven days of receipt by him, failing which, it shall be considered to be correct.

46.—The Council may accept communications from persons who are not members of the Institution, and allow them to be read at the ordinary or annual general meetings of the Institution.

47.—A paper in course of publication cannot be withdrawn by the writer, without the permission of the Council.

48.—The copyright of all papers accepted for publication in the *Transactions* shall become vested in the Institution, and such communications shall not be published for sale or otherwise without the written permission of the Council.

49.—Thirty copies of each paper and the accompanying discussion shall be presented to the writer free of cost. He may also obtain additional copies upon payment of the cost to the Secretary, by an application attached to his paper. These copies must be unaltered copies of the paper as appearing in the publication of the Institution, and the copy shall state that it is an "Excerpt from the *Transactions* of The Institution of Mining Engineers."

50.—The Federated Institutes may receive copies of their own portion of the publications in respect of such of their members as do not become members of the Institution, and shall pay 10s. per annum in respect of every copy so supplied; and similar copies for exchange shall be paid for at cost price.

51.—A list of the members, with their last-known addresses, indicating the Federated Institute to which they belong, shall be printed annually in the publications of the Institution.

52.—The publications of the Institution shall only be supplied to members, and no duplicate copies of any portion of the publications shall be issued to any member or Federated Institute unless by order of the Council.

53.—The annual volume or volumes of the publications may be sold, in the complete form only, at such prices as may be determined from time to time by

the Council:—To non-members for not less than £3; and to members who are desirous of completing their sets of the publications, for not less than 20s.

54.—The Institution, as a body, is not responsible for the statements and opinions advanced in the papers which may be read or in the discussions which may take place at the meetings of the Institution or of the Federated Institutes.

VIII.—Medals and other Rewards.

55.—The Council, if they think fit in any year, may award a sum not exceeding sixty pounds, in the form of medals or other rewards, to the author or authors of papers published in the *Transactions*.

IX.—Property.

56.—The capital fund shall consist of such amounts as shall from time to time be determined by resolution of the Council.

57.—The Institution may make use of the following receipts for its expenses:—

(*a*) The interest of its accumulated capital fund;
(*b*) The annual subscriptions; and
(*c*) Receipts of all other descriptions.

58.—The Institution may form a collection of papers, books and models.

59.—Societies or members who may have ceased their connexion with the Institution shall have no claim to participate in any of its properties.

60.—All donations to the Institution shall be acknowledged in the annual report of the Council.

X.—Alteration of Bye-laws.

61.—No alteration shall be made in the bye-laws of the Institution, except at a special meeting of the Council called for that purpose, and the particulars of every such alteration shall be announced at their previous meeting and inserted in the minutes, and shall be sent to all members of Council at least fourteen days previous to such special meeting, and such special meeting shall have power to adopt any modification of such proposed alteration of the bye-laws, subject to confirmation by the next ensuing Council meeting.

TRANSACTIONS

OF

THE INSTITUTION

OF

MINING ENGINEERS.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE,
FEBRUARY 11TH, 1905.

MR. W. C. BLACKETT, VICE-PRESIDENT, IN THE CHAIR.

THE LATE SIR LOWTHIAN BELL, BART.

The CHAIRMAN (Mr. W. C. Blackett), referring to the lamented death of Sir Lowthian Bell, said that no words of his could express the loss which this Institute had suffered thereby. Taking the lead, as Sir Lowthian always did, not only in theory but in practice, the late baronet among his multitudinous duties never spared himself in lending to this Institute a large share of his time and valued assistance; in recording their own deep sense of loss, he was sure that the members would also express their condolence and sympathy with the relatives.

Mr. JOHN SIMPSON seconded the vote, which was adopted.

The SECRETARY read the minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on January 28th and that day, and of the Council of The Institution of Mining Engineers.

The Report of the Corresponding Societies' Committee of the British Association for the Advancement of Science was read.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. MATTHEW JOHN BATES, Mechanical Engineer, Highbury, Stocksfield-upon-Tyne.

Mr. WALTER REMINGTON BATESON, Mining Engineer, Mina de San Domingos, Mertola, Portugal.

Mr. ROBERT HENRY CRAVEN, Mining Engineer, Sestri Levante, Italy.

Mr. GEORGE DOUGLAS GIBSON, Mechanical Engineer, Vause Road, Durban, Natal, South Africa.

Mr. HUGH LATIMER, Colliery Manager, Eldon Colliery, Bishop Auckland.

Mr. PERCY EWBANK LEE, Colliery Manager, Pontop Colliery, Annfield Plain, R.S.O., County Durham.

Mr. HUGH LIDDELL, Mechanical Engineer, Aden House, Jones Street, Birtley, R.S.O., County Durham.

Mr. MARSHALL GREENE MOORE, Mining Engineer and General Superintendent, Mining Department, Cambria Steel Company, 840, Napoleon Street, Johnstown, Pennsylvania, United States of America.

Mr. WILLIAM DAVID OWENS, District Superintendent, Lehigh Valley Coal Company, 239, Philadelphia Avenue, Pittston, Pennsylvania, United States of America.

Mr. FRANCIS WILLIAM PAYNE, Consulting Mechanical Engineer, Government Insurance Building, Dunedin, New Zealand.

Mr. JOSEPH THOMAS PULLON, Civil and Mining Engineer, 75, Victoria Road, Headingley, Leeds.

Mr. T. A. RICKARD, Mining Engineer, 261, Broadway, New York City, United States of America.

Mr. ABRAHAM WRIGHT, Colliery Manager, East Indian Railway, Engineering Department, Giridih, Bengal, India.

ASSOCIATE MEMBERS—

Mr. HERBERT NEVILE-SMITH, Chilliwack, British Columbia.

Mr. JOHN POSTLETHWAITE, Chalcedony House, Eskin Place, Keswick, Cumberland.

Mr. BASIL SADLER, Craigmore, Lanchester, Durham.

ASSOCIATES—

Mr. JOHNSON BATES, Enginewright, 5, Grange Villa, Chester-le-Street, County Durham.

Mr. PERCY CROWLE, Iron-ore Miner and Instructor of Mining Classes, 51, Mainsgate Road, Millom, Cumberland.

Mr. CHRISTOPHER ELLIOTT, Enginewright, 11, Front Street, East Stanley, County Durham.

Mr. THOMAS WEDDLE ENGLISH, Under-manager, Halton Colliery, Whittington, Corbridge-upon-Tyne.

Mr. JOHN LONGRIDGE, Mining Official, 27, Mary Agnes Street, Coxlodge, Gosforth, Newcastle-upon-Tyne.

Mr. John Thomas Reed, Master Shifter, 22, Evelyn Terrace, Stanley, R.S.O., County Durham.

Mr. Christopher Wilson, Assistant Mechanical Engineer, Beamish and West Pelton Collieries, 72, Tower Street, Gateshead-upon-Tyne.

Student—

Mr. Herbert Sydney Benson, Mining Student, Shield Row Hall, Stanley, R.S.O., County Durham.

DISCUSSION OF MR. H. W. G. HALBAUM'S PAPER ON "THE ACTION, INFLUENCE AND CONTROL OF THE ROOF IN LONGWALL WORKINGS."*

The Chairman (Mr. W. C. Blackett), referring to his remarks on this paper at the previous meeting, stated that the author's reply seemed to indicate that his view as to the possibility of lateral movement in overlying strata had been misunderstood, especially with regard to "draw." His (Mr. Blackett's) remarks applied to the immediately overlying stone, uncomplicated in any way by "jacks" or "hitch leaders." Of course, the phenomena in the case of falls must be different when the surface was reached, as the substances met with were altogether different—sand, clay, etc., and it was impossible to say what would happen. In confining his remarks to the roof, he meant the roof of the underground workings, without reference to the surface, where it became so complicated by alluvial and other matter that they could not trace the effects through it.

DISCUSSION OF MR. E. O. FORSTER BROWN'S PAPER ON "A METHOD OF PACKING EXCAVATIONS IN COAL-SEAMS BY MEANS OF WATER."†

Mr. E. O. Forster Brown said that he had omitted to mention in the paper the size of the material used in the packing; it was very seldom more than 3 inches in diameter, and for long distances not usually more than 1½ inches, otherwise the material had difficulty in passing around curves in the pipes. In Silesia, it was found that a week was usually sufficient to clear clayey water when clay was used for packing. The actual cost of packing excavations from which 324,000 tons of coal had been wrought

* *Trans. Inst. M.E.*, 1904, vol. xxvii., page 205; and vol. xxviii., page 316.

† *Ibid.*, 1904, vol. xxviii., page 325.

in one year at Myslowitz colliery, the tubes used being estimated as lasting only that time, was £6,000, and of this amount, £2,500 was spent in getting the material to the funnels. A cubic foot of sand was estimated to require 2 cubic feet of water for its conveyance. When the paper was read, several remarks were made as to the difficulty of obtaining a sufficient supply of material, as, for instance, in Northumberland, or in a neighbourhood worked under valuable surface. He had been informed that about 2,000,000 tons of material were dredged annually from the river Tyne and taken to sea, at a freight-cost of about 4d. per ton. He understood that this material could be landed at a very slightly increased cost on the banks of the Tyne, where it could be utilized, as the mining operations in the neighbourhood were made under valuable surface.

The CHAIRMAN (Mr. W. C. Blackett) asked whether the sand used to replace the 324,000 tons of coal removed at Myslowitz colliery had the same volume or the same weight as the coal.

Mr. FORSTER BROWN said he assumed that a cubic foot of sand would nearly replace a cubic foot of coal. The packing usually represented 90 per cent. of the space occupied by the coal.

Mr. EDWARD HETON ROBERTON's paper on "The Action, Influence and Control of the Roof in Longwall Workings" was read as follows:—

THE ACTION, INFLUENCE AND CONTROL OF THE ROOF IN LONGWALL WORKINGS.

By E. H. ROBERTON.

The control of the roof in longwall mining is a widely varied, as also a highly important subject, embracing as it does such problems as the protection of miners at the coal-face, of putters and ponies in the gateways from accidents caused by falls of stone, and, on a more comprehensive scale, the laying out of the workings in such a way as to ensure the upkeep of airways and waterways in the waste with the least possible trouble and expense. Again, it is necessary to prevent the coal from being unduly crushed as the weight of the roof comes on, and at the same time to utilize the roof-weight to assist the hewers at the face in the working of the coal. The methods by which the above problems may be solved differ greatly, being dependent on the relative hardness of the coal, the roof and the floor, and on the depth, thickness and inclination of the seam. With the object of attempting to particularize these methods, the writer proposes to take as examples six seams (Table I.) in which he has had experience, all of which are being, or have been, worked by longwall methods.

The general method of laying out a district in a thin coal-seam worked by longwall is shown in Fig. 1 (Plate I.). The ropeways are laid in the goaf, the ropes being advanced nearer the face as the roof settles down into its final position. The distance between the gateways is 33 feet.

In thick seams, barriers of coal are left for the haulage-roads, the width of the barriers varying with the depth of the seam. The distance between the gateways is 54 feet. The general mode of laying out the workings is similar to that of the other seams.

The A seam is very suitable to be taken as a standard seam, the roof being uniformly good and requiring very little timber.

Owing partly to the toughness of the stone, and partly to the small distance through which the necessary settlement takes place, the roof bends into its new position generally without breaking. Figs. 2, 3 and 4 (Plate I.) show the gateway-faces and the method of packing: the larger stones being built to form a wall about 3 feet from the coal-face and down the side of the gateway, and the rubbish is packed inside. All props are removed from the goaf, so that the settlement of the roof shall not be hindered.

TABLE I.—THE CONDITION OF THE SEAMS.

Name of Seam.	Thickness of Seam.	Description of Roof and Thickness.	Description of Floor and Thickness.	Depth of Seam.
	Ft. In.	Feet.	Feet.	Feet.
A.	2 4	Strong post ... 12	Seggar-clay ... ... 2 Grey metal ... ... ?	540
B.	2 7	White post and blue metal partings ... 30	Seggar-clay ... 3 Whin girdle ... 1½	360
C.	2 6	Grey metal .. 9	Seggar-clay ... ... 2½ Strong metal and post ?	540
D.	3 0	Very soft grey metal 30	Strong white post ... ?	720
E.	7 0	Strong post 18 to 24	Seggar-clay ... ... 3 Grey post ... ... ?	300
F.	7 0	Soft grey metal ... 6	Seggar-clay ... ... 3 Grey post ... ... ?	300

Figs. 1 and 2 (Plate I.) also show the method of "hipping" the coal-face, that is, keeping each gateway a few feet in front of, or behind, the next one. This system prevents the formation of a continuous straight line of face, which is conducive to a sudden break-away of the roof at the coal-face; but it crushes the coal in the outlying corners where the weight comes on, especially if the roof and floor are strong. Crushing, however, is very greatly diminished by careful packing. Hipping is not so necessary in low seams, especially if the roof is good and the coal hard. On the contrary, it is often more beneficial to allow the face to advance in a continuous line, as the coal then works better. This latter method will be more universally employed, as the use of coal-cutting machinery becomes more general: the enhanced rate with which the coal-face advances lessening the danger of a break of the roof along the coal-face.

Fig. 2 shows the point in each gateway where bending of the roof may be expected, and possible falls of stone may occur. This is approximately on the line, EF, joining the points where the roof is supported by the corners of the coal. In the A seam, a fracture of the roof-stone occasionally occurs in the gateways at this point, necessitating the use of timber, but as the roof straightens out again in its new resting-place the frame of stone is upheld firmly by side-pressure, and the gears or sets of timber may be removed. In the B seam, where the roof is good, though more brittle, a greater quantity of timber is used in the gateways; but occasionally there are somewhat long stretches where timber is not used. In the C seam, the roof when " green " is hard and firm, owing to a band of tough black shale, 3 or 4 inches thick, lying immediately above the coal. When, however, the roof is once broken, it shows itself to be of a short nature, requiring regular timbering along the gateways. This characteristic of the roof has been the cause of barriers of coal being left to support the roof in the main haulage-roads, a bottom-canch of stone being taken up in order to keep the black shale intact, rendering unnecessary the use of timber.

When a coal-barrier is left to support a road, the barrier cross-heading is not formed next to the solid coal, but a stone-pillar, 9 to 12 feet thick, is built between it and the coal, so that, when the stone breaks off at the coal-edge, the broken part of the roof is upheld by the stone-pillar, leaving a better roof for the cross-heading (Fig. 5, Plate I.).

The D seam at first presented a certain amount of difficulty, owing to the tender nature and the great thickness of the soft strata immediately above the coal, which, though apparently fairly strong when "green," very soon begin to crumble under the action of the air. It was found impracticable to drive narrow places, and leave barriers for the haulage-roads, as the roof, being so much softer than the coal and floor, cut itself close to the coal and brought so much weight to bear that it broke the baulks and girders, and closed the place. After this, it was decided to take out the coal altogether by longwall. The original main haulage-road has been cleared and arched with bricks, and a rope haulage-road made in the goaf at right angles to it. In the gateways, the props are very soon broken owing to the

unyielding nature of the floor, and a great deal of timbering is required; but when the roof has once settled the quantity is not excessive. The greatest trouble to be overcome was caused by falls, which were constantly occurring at the turns into the cross-headings and gateways. These have been very greatly reduced by the introduction of wooden cogs into the corners of the pillars, at the entrance to each place, which prevent the packwalls from being crushed out by side-pressure and breaking the timber—a fruitful cause of falls of stone.

In working the E seam, a high seam, it was soon found, if the coal-faces of adjoining gateways were allowed to get on nearly level terms, that the roof broke close to the face, and caused much more trouble than a similar occurrence in a thin seam. For this reason, great care is taken to keep each gateway about 45 feet in advance of the succeeding gateway. The principal area of possible danger to the hewers is at the "loose-end" of the coal-face, where the lines of roof-fracture are liable to occur. At this point, owing to the lines of coal-face, the roof tends to bend in two directions, one parallel to the gateways and the second at right angles to them. This causes two lines of fracture at right angles to each other, and creates the danger of loose frames of stone being formed in the roof, which may fall without warning. Protection is afforded by means of cogs of timber, which cause the roof to break off at a point actually several feet distant from the loose end (Fig. 6, Plate I.).

The roof is similar to that of the A seam, strong and tough, and, despite the height of the seam, can be made to bend into its new position without seriously breaking in the gateways. Advantage is taken of the fact that the floor is of seggar-clay, the props being set at the sides of the gateways without sole-trees, and gradually sinking into the firm clay as the roof settles down. This equalizes the pressure on that part of the roof which is between the coal-face and the settled portion, and lengthens the life of each prop, as the subsidence of the roof (nearly 4 feet) would otherwise break all the props. The roof in each gateway is ripped down, from 3 to 5 feet thick, to provide stones for building the packwalls, which are spaced about 8 feet apart, the space between being filled with band-stone and rubbish. The roof in the waste, between the packs, is left unsupported, except for occasional stone nogs, about 8 feet square (Fig. 6, Plate I.).

An attempt was made to work the F seam by the longwall method; but it was abandoned, owing to the soft, clayey nature of the stone ripped from the roof, which, when built in the form of packwalls, was squeezed out into the gateways by the roof-weight. There was a strong post-stone above the grey metal, but it was too high up to be shot down and used for building the side-walls.

The principal factor in ensuring a safe and gradual subsidence of the roof of a longwall gateway is careful packing. The rubbish should be stowed close against the roof, the packs should be kept well forward near the face, and all props should be withdrawn from the goaf: the object being to prevent local inequalities in the distribution of pressure. In a high seam, it is impossible to pack the goaf as efficiently as in a low seam, owing to the scarcity of stowing-material, but by skilful building and stowing of the packwalls, the gateways may be kept in good and safe condition.

A gradual subsidence of the roof is additionally desirable, because breaks in the roof are liable to release water or gas. Water is often released where a trouble is passed, but this may be generally prevented by taking care to pack all places close to the trouble with hard post-stone, imported if necessary. In cases where a line of "coal-edge" is left because of a boundary or shaft-pillars, or for any other reason, the strata above are cut at the coal-edge to a considerable height above the seam, and a great weight is brought to bear on the pack at that point, the roof often being much broken up. Water, too, is sometimes released. For this reason it is found more convenient and economical to keep good the next gateway but one to the coal-edge, if a permanent road is needed there for the purpose of ventilation, drainage, or travelling.

The action of the roof-weight on the coal varies according to the surrounding conditions. Generally speaking, the roof has little influence on the coal in working to the dip compared with that experienced when working to the rise. An important item is the rate with which the coal-face advances. If the seam is hard and difficult for the hewers, the rate of advance of the coal-face may be retarded, so as to allow the roof-weight more time to exert

its influence; whereas if the seam is soft and liable to be crushed too easily, less time should be allowed for the roof-weight to act, by accelerating the rate of advance of the coal-face. Other considerations, too, assert themselves. For example, in the D seam, the coal-face is advanced as quickly as possible, so as to ensure a "green" roof above the hewers, as the roof deteriorates so rapidly under atmospheric action. In this seam, the influence, or rather the crushing effect of the roof on the coal is small, owing to the softness of the roof compared with the coal. At one period, an isolated peninsula of coal was left for several weeks, and when ultimately got it was found to have hardly suffered at all in quality, though the roof on all sides was fallen close. Curiously enough, the influence of the roof-weight, so far as helping the hewers is concerned, is good.

In low seams, especially when working to the rise, the roof-weight renders the coal much easier to kirve, greatly reducing the quantity of explosive used; while, in high seams, such as the E seam, the roof is made to do practically all the work, the hewers simply dressing down the coal-face with the picks, and filling the coal into tubs. This naturally causes a rapid advance of the coal-face of the E seam, which is desirable, as it is conducive to a greater space between the coal-face and the bending point of the roof.

It is sometimes better to work the coal "headways" instead of the usual "bordways"; the seam in the former case producing a greater percentage of round coal. In a soft seam, especially, it may be found advantageous, but in a hard seam it will probably augment the hewing price, as the coal is decidedly more difficult to work. It is occasionally found that the roof is more tractable to deal with, but this depends on the lines of cleavage in the roof and can only be determined by trial.

The Chairman (Mr. W. C. Blackett) moved a vote of thanks to Mr. Roberton for his interesting paper.

Mr. T. E. Forster seconded the resolution, which was cordially approved.

Mr. James Ashworth's "Observations on Water-sprayed or Damped Air in Coal-mines" was read as follows:—

OBSERVATIONS ON WATER-SPRAYED OR DAMPED AIR IN COAL-MINES.

By JAMES ASHWORTH.

The recently expressed opinions of several of H.M. inspectors of mines on water-sprayed or damped air ought to draw serious attention to it, as the majority of these officials apparently place a high value on watering as a preventive and also as a restrictive agent against the extension of an explosion of coal-dust. Thus, Mr. J. B. Atkinson has said that "if all the dangers attending shot-firing in mines are thoroughly understood and guarded against [by watering], there seems to be no reason why shots should not be fired with safety."*

Mr. J. T. Robson, in his report on the Tylorstown colliery explosion, said "that the use of high explosives led the management to depend more on the supposed greater safety . . . than is warranted, and that this led to insufficient watering."† And, in the report on the explosion at the Universal colliery, he said that he entirely agreed "with Prof. W. Galloway that shot-firing is the most prolific cause of explosions in coal-mines;"‡ and that the third point referred to by the jury, namely, that it should be "strictly compulsory to have the bottom, sides and top of the roads of collieries so well watered as to make it impossible for coal-dust to spread on an explosion,"§ was highly important. "It is now universally admitted that coal-dust is a 'greater enemy' than even fire-damp, yet it is undoubtedly a fact that sufficient attention is not always paid to the prevention of its accumulation, and, in my opinion, this can only be done by constant and efficient watering."‖

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 467.

† "Report to the Right Honourable the Secretary of State for the Home Department on the Explosion at Tylorstown Collieries on the 27th January, 1896," by Mr. J. T. Robson, *Reports to the Right Honourable the Secretary of State for the Home Department on the Tylorstown Colliery Explosion*, by Mr. Robert Woodfall and Mr. J. T. Robson, 1896, page 18.

‡ "Report," by Mr. J. T. Robson, *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at the Universal Colliery, Glamorganshire, on May 24th, 1901*, by Prof. W. Galloway, Mr. S. T. Evans and Mr. J. T. Robson, 1902, page 31.

§ *Ibid.*, page 31. ‖ *Ibid.*, page 32.

Mr. J. S. Martin, in his report on the explosion at Llanbradach colliery, said that "colliery managers and workmen must in the future more thoroughly recognize the danger arising from dust, and introduce some satisfactory means for bringing a jet of water to play upon the roof and sides. . . . . . It must also be borne in mind that where there is much dust, water takes little effect at first, and that it must be very liberally distributed for its use to be efficient."* He was, however, able to say, in his report on the explosion at the MacLaren colliery,† that good use had been made of the watering arrangement, and to it might be attributed the limited loss of life; this was perhaps the first practical proof that artificial watering had limited the effects of what might otherwise have proved a very widespread and much more disastrous explosion.

Messrs. J. T. Robson, H. Hall and J. S. Martin agreed with the recommendation of the jury, at the enquiry on the Albion explosion, that shot-firing in timber should be absolutely prohibited:‡ in this case, the verdict was not qualified by any suggestion as to efficient watering.

Mr. H. Hall, reporting on his experiments at Skelmersdale colliery to the Royal Commission on Explosions from Coal-dust in Mines, remarked that "mines which are naturally of a dry and dusty character cannot be artificially damped so as to render gunpowder safe, ... It is deserving of consideration and experiment to test whether a coal-dust explosion would be stopped in its course by a certain length of roadway being constantly kept in a wet condition. Personally, I think such a plan would not prove effective in consequence of what may be termed the pioneering cloud of dust which precedes the flame."§

* *Report to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at Llanbradach Colliery, Llanbradach, near Cardiff, on the 10th September, 1901*, by Mr. J. S. Martin, 1901, page 8.

† "Report," by Mr. J. S. Martin, *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at MacLaren Colliery (No. 1 Pit), Abertysswg, on the 3rd September, 1902*, by Mr. S. T. Evans and Mr. J. S. Martin, 1903, pages 4 and 7.

‡ "Report on Albion Colliery Explosion," by Mr. J. T. Robson, Mr. Henry Hall and Mr. Joseph S. Martin, *Reports to the Right Honourable the Secretary of State for the Home Department on the Disaster at Albion Colliery, Cilfynydd, near Pontypridd, on the 23rd June, 1894*, by Mr. J. Roskill and by Mr. J. T. Robson, Mr. Henry Hall and Mr. Joseph S. Martin, 1894, page 39.

§ *Report made by desire of the Secretary of State to the Royal Commission on Explosions from Coal-dust in Mines*, by Mr. Henry Hall, 1893, page 15.

Mr. H. Hall, however, proved by the following experiments that a pioneering cloud of dust was not a necessary factor in a coal-dust explosion. In the first experiment, 2 cwts. of dust from Albion colliery was thrown into a disused pit, 150 feet in depth and 7 feet in diameter, at Skelmersdale; and, 30 minutes afterwards, a shot of 1½ pounds of gunpowder was fired from a cannon hung vertically at the bottom of the pit, with the result that a very violent explosion occurred, and a body of flame, 60 feet high, was seen above the pit-top. Forty-five minutes after this, another shot, of the same weight, was fired, without adding any additional coal-dust, and again there was an explosion, and a flame, 15 feet, above the pit-top.* The second experiment was equally convincing, in which 1½ cwts. of dust from the Hutton seam, Murton colliery, was used, and 3 minutes after putting in the dust, a charge of 10 ounces of ammonite was fired, without an explosion resulting; 11 minutes later, another shot (8 ounces of roburite) was fired without adding further coal-dust, and again there was no explosion; 25 minutes later, 1½ pounds of gunpowder was fired without adding any coal-dust, and this time a very violent explosion was produced, with flame, 60 feet, above the pit-top.†

Prof. H. B. Dixon remarked, in the report on the explosion at Radstock colliery, that "the path travelled by the flame was not 'dusty' in the sense in which that word is ordinarily used in mines."‡

Fortunately, Mr. H. Hall recorded the state of the weather and the hygrometrical readings§ on eight of the days of his experiments, thus allowing the condition of the air to be compared with that to which we are accustomed in mines. On July 6th, 1887, when the dust from Albion colliery was tested, the dry-bulb thermometer stood at 78° Fahr. and the wet bulb at 65° Fahr., showing that the air was rather dry and contained 4·8 grains of water; and on July 8th, 1887, when the Hutton seam dust from Murton colliery was tested, the dry bulb was 75° Fahr.

* *Report made by desire of the Secretary of State to the Royal Commission on Explosions from Coal-dust in Mines*, by Mr. Henry Hall, 1893, page 11.

† *Ibid.*, page 5.

‡ Appendix XXI., by Prof. H. B. Dixon, *Minutes of Evidence taken before the Royal Commission on Explosions from Coal-dust in Mines; with Appendices and Index*, vol. ii., 1894, page 92.

§ *Report made by desire of the Secretary of State to the Royal Commission on Explosions from Coal-dust in Mines*, by Mr. Henry Hall, 1893, page 19.

and the wet bulb 68° Fahr., showing a content of 6·2 grains of water per cubic foot. The highest percentage of saturation was on June 23rd, 1887, when rain was falling nearly all day, and the dry bulb registered 54° Fahr. and the wet bulb 52° Fahr.: these conditions giving 4·1 grains of water per cubic foot, or 86 per cent. of saturation. When the dust from Albion colliery was tested, the saturation on the surface was only 47 per cent., and in the case of the Hutton seam dust 66 per cent. It is practically certain that on the days when the dry-bulb thermometer registered 74°, 75°, 78° and 82° Fahr., the air in the shaft would be cooler, and would also contain more moisture than on the surface; and the effect of this alteration in temperature may be realized by referring to Mr. W. N. Atkinson's report on the "First pit," Bristol and Somerset coal-field,* at a depth of 684 feet. At the surface, the dry bulb was 66° Fahr. and the wet bulb 57° Fahr., indicating 3·9 grains of water per cubic foot. In the Hard vein, 2,700 feet from the shaft, the dry bulb was 57½° Fahr. and the wet bulb was also 57½° Fahr., indicating complete saturation with 5·3 grains of water per cubic foot; and in the High vein return-airway, the dry bulb was 63° Fahr. and the wet bulb 63° Fahr., indicating complete saturation with 6·4 grains per cubic foot.

When Mr. H. Hall tested the dust from the Radstock No. 6 seam (July 7th, 1887), the temperatures on the surface were: dry bulb 82° Fahr. and wet bulb 68° Fahr.,† showing the water-content to be 5·2 grains, or nearly the same as in Mr. Atkinson's experiments; and, although he did not obtain an explosion, yet he found the dust charred in the first experiment for a distance of 75 feet, and in the second experiment to 120 feet.‡ These experiments, as well as those previously quoted, may be usefully compared with an experiment made on June 23rd, 1887, on dust from the Aberdare Four-feet seam of the Lewis Merthyr colliery, when at the surface the dry bulb was 54° Fahr. and the wet bulb 52° Fahr.,§ showing the low content of 3·6 grains of water per

* "Report upon the Condition of the Radstock and Forest of Dean Collieries," by Mr. W. N. Atkinson, *First Report of the Royal Commission on Explosions from Coal-dust in Mines; with Minutes of Evidence and Appendices*, 1891, appendix xi., page 176.

† *Report made by desire of the Secretary of State to the Royal Commission on Explosions from Coal-dust in Mines*, by Mr Henry Hall, 1893, page 19.

‡ *Ibid.*, page 12. § *Ibid.*, page 19.

cubic foot of air. Although this dust was taken from the same seam of coal as the highly explosive coal-dust of the Albion colliery, yet the first experiment only yielded an explosion which extended to the pit-top, and the two following experiments only resulted in charring to distances of 45 and 51 feet respectively.*

Without more extended experiments being made, and records of the condition of the air in the pit being kept, it would be unsafe to assert that air containing only 3·6 grains of water per cubic foot, is a safer atmosphere in which to fire shots than one containing 6·2 grains. Still, it has that appearance, more particularly if it be observed that at the time when the Albion dust was tested (June 9th, 1887), the dry bulb reading 67° Fahr. and the wet bulb 62° Fahr., the air contained 5·3 grains of water; † it was therefore 73 per cent. of saturation, and caused a more violent explosion than any that had preceded it.

Tables I. and II. will, however, demonstrate more clearly that the surface-temperatures and the percentage of saturation vary considerably, and that, when this air is taken down the pit, these values immediately commence to alter, and the variations become less marked the nearer the air approaches to the upcast-shaft. Table I. contains extracts from barometrical, hygrometrical and water-gauge observations made during the months of March, April and May, 1899, at a colliery working a dry and dusty coal-seam at a depth of 2,100 feet, and where no serious explosion of gas or dust had yet occurred. The observations made by Prof. W. Galloway at the Universal colliery‡ are added, for the sake of comparison. Table II. records the weight in grains per cubic foot of air and the weight of water carried in suspension at the surface, at the bottom of the downcast-shaft, and at the bottom of the upcast-shaft, and the differences of these weights and the sum of these differences. The uniformity of the heat, and consequently of the water-content of the air, at the foot of the upcast-shaft arrests attention; thus, the variation of temperature ranged

* *Report made by desire of the Secretary of State to the Royal Commission on Explosions from Coal-dust in Mines*, by Mr. Henry Hall, 1893, page 11.

† *Ibid.*, page 19.

‡ "Report," by Prof. W. Galloway, *Reports to His Majesty's Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred at the Universal Colliery, Glamorganshire, on May 24th, 1901*, by Prof. W. Galloway, Mr. S. T. Evans and Mr. J. T. Robson, 1902, page 9.

TABLE I.—METEOROLOGICAL AND OTHER OBSERVATIONS.

No. of Observation.	At the Surface.			Intake-air at Bottom of Downcast-shaft.			Water-gauge.	Return-air at Bottom of Upcast-shaft.		
	Barometer.	Thermometer.		Barometer.	Thermometer.			Barometer.	Thermometer.	
		Dry Bulb.	Wet Bulb.		Dry Bulb.	Wet Bulb.			Dry Bulb.	Wet Bulb.
I.—COLLIERY, OVER 2,100 FEET DEEP, AND VENTILATED BY A FURNACE.										
	Inches.	Degrees Fahr.	Degrees Fahr.	Inches.	Degrees Fahr.	Degrees Fahr.	Inches.	Inches.	Degrees Fahr.	Degrees Fahr.
1	29·57*	35	32	31·70*	53	44½	—	31·63*	85½	70½
2	29·97†	50½	47½	32·43†	60½	53½	1·6	32·37†	84	70
3	30·35†	39	36	32·72†	55	47½	2·0	32·67†	84½	70
4‡	30·20†	39	38½	32·38†	54	48	2·2	32·30†	83	70
5§	29·70*	33	31½	31·87*	48½	40	2·6	31·80*	82	68½
6	29·69*	54½	51½	31 96*	62½	56	1·8	31·82*	82	69½
7	30·22*	59½	48	32·40*	63	52	1·8	32·33*	83½	70
8‖	29·80*	53½	51½	32·06*	63½	57½	1·8	32·00*	83	71
II.—UNIVERSAL COLLIERY, 1,605 FEET DEEP, AND VENTILATED BY A FAN.										
1	29·25	61½	54¼	31·04	60	56¼	1·7	30·90	70¾	69¾
III.—DAY-EYE COLLIERY, VENTILATED BY A FAN.										
1**	25·98†	67	52	26·05†	58	53	0·8	25·96†	47	46
2††	26·19†	46	42	26·13†	53	49	0·8	26·16†	47	46

* Mercurial barometer. † Aneroid barometer. ‡ Foggy at the surface. § Snowing at the surface. ‖ Raining at the surface. ** Fine at the surface. †† Rain and hail at the surface.

TABLE II.—CALCULATIONS FROM METEOROLOGICAL AND OTHER OBSERVATIONS.

No. of Observation.	At the Surface.		Bottom of Downcast-shaft.		Water-gauge.	Bottom of Upcast-shaft.		Difference in Weight of a Cubic Foot of Air.		The Sum of the Differences.
	Weight of Air per Cubic Foot.	Weight of Water-vapour per Cubic Foot of Air.	Weight of Air per Cubic Foot.	Weight of Water-vapour per Cubic Foot of Air.		Weight of Air per Cubic Foot.	Weight of Water-vapour per Cubic Foot of Air.	Between the Surface and the Bottom of the Downcast-shaft.	Between the Bottom of the Downcast-shaft and the Bottom of the Upcast-shaft.	
I.—COLLIERY, OVER 2,100 FEET DEEP, AND VENTILATED BY A FURNACE.										
	Grains.	Grains.	Grains.	Grains.	Inches.	Grains.	Grains.	Grains.	Grains.	
1	554·4	1·7	572·8	2·4	—	535·3	5·5	18·4	37·5	55·9
2	544·4	3·3	575·8	3·6	1·6	549·4	5·6	31·4	26·4	57·8
3	564·0	2·1	588·9	2·8	2·0	554·4	5·6	24·9	34·5	59·4
4*	563·0	2·6	583·5	3·0	2·2	549·1	5·3	20·5	34·4	54·9
5†	559 0	1·9	582·9	1·9	2·6	541·5	5·4	23·9	41·4	65·3
6	534·1	3·9	566·0	4·0	1·8	541·9	5·6	31·9	24·1	56·0
7	539·0	2·5	573·9	3·0	1·8	549·1	5·7	34·9	24·8	59·7
8‡	537·0	3·9	566·7	4·4	1·8	543·8	6·1	29·7	22·9	52·6
II.—UNIVERSAL COLLIERY, 1,605 FEET DEEP, AND VENTILATED BY A FAN.										
1	519·2	3·7	552·2	4·4	1·7	536·9	7·8	33·0	15·3	48·3
III.—DAY-EYE COLLIERY, VENTILATED BY A FAN.										
1§	457·6	2·7	464·9	3·8	0·8	474·8	3·4	Day-eye	9·9	17·2
2‖	480·1	2·6	470·1	3·4	0·8	477·8	3·4	Day-eye	7·7	16·7

* Foggy at the surface. † Snowing at the surface. ‡ Raining at the surface. § Fine at the surface. ‖ Rain and hail at the surface.

from 82° to 85½° Fahr., and the water-vapour from 5·4 to 6·1 grains. On the coldest day (No. 5), the natural warmth of the strata increased the temperature of the air from 33° to 82° Fahr. or 49°, and on the warmest day (No. 7) from 59½° to 83½° Fahr. or 24°; and the weight of water-vapour was increased from (No. 5) 1·9 to 5·4 or 3·5 grains, and (No. 7) from 2·5 to 5·7 or 3·2 grains. On the coldest day, the increase in temperature in descending the shaft was from 33° to 48½° Fahr. or 15½°, and on the warmest day from 59½° to 63° Fahr. or only 3½°, and, therefore, it will be clearly seen that mine-air quickly attains a nearly normal temperature all the year round.

Probably the most serious divergence in figures will be found when a comparison of the water-gauge readings is made with the differences in the last three columns, but it confirms the writer in his opinion that the water-gauge is not nearly so useful an instrument as it is generally thought to be: that it is, in fact, a clumsy instrument, which does not afford such accurate information as modern mining demands, and he therefore suggests that barometrical and hygrometrical observations should be made daily, or whenever the fireman or deputy inspects a district.

The power of the ventilation depends on the difference of pressure between the downcast-shaft and the upcast-shaft: but in the ordinary formula to ascertain the value of the motive column $M = D\ (T - t) \div (T - 459)$, no account is taken of the influence exerted by the content of water, and it is now suggested that the sum of the differences in the weights per cubic foot of air between the surface and the bottom of the downcast-shaft, and between the latter and the bottom of the upcast-shaft, should be taken as the true indication of what may, for the moment, be termed the water-gauge. Wherever this is done, the general manager and the manager will have at their service information of a most valuable character, and will be able to check the ventilation-reports by means which cannot easily be faked, and are not fairly disclosed until the calculations have been made. Probably, in course of time, rules may be evolved which will direct attention to any serious increment of fire-damp in the return-air, in a somewhat similar way to the following example, where, by comparing the observations taken in the pit 2,100 feet deep, with those from the Universal colliery, it may be seen that watering or

spraying was not carried out so extensively in the former as in the latter colliery, because the latter shows that the return-air was within 0·5 grain of saturation, whereas the former could have carried 5·9 grains more water-vapour per cubic foot.

Table II. also shows, when rain was falling on the surface, that the intake-air at the pit-bottom was most heavily charged with moisture, namely, 4·4 grains, and that the increase of temperature in the air as it passed through the mine, enabled it to carry a greater weight of water at the point where it was least required, namely, in the return-air. What point of excellence in saturation it is possible to attain on the intake-air roads of collieries is probably most clearly demonstrated in Mr. H. W. Martin's evidence;* thus, at his second spray, 618 feet from the pit, the air at 51° was saturated by only 4·2 grains of moisture; at 3,732 feet the temperature had increased to 64° Fahr., and the moisture to 6·6 grains; and, at the coal-face, the temperature had become 67° Fahr., and the moisture 7·3 grains. These experiments also showed that the heat of the air at the coal-face was reduced 2° when the water-sprays were at work, and when the sprays were not at work the natural heat of the mine increased the heat of the air by 2°, and evaporation, between the shaft-bottom and the distance of 3,732 feet, added 2·1 grains to that already in the air coming down the shaft, and 1·1 grains more between that point and the coal-face. Thus it will be seen, that if an explosion had occurred under these conditions, the restraining influence of the water over a length of 1,500 feet from the face, would be less than 7·3 grains of moisture, and between that point and the pit-bottom (3,000 feet) 6·2 to 4·1 grains of moisture and possibly in addition there might be, at some unknown point, a spray in active operation.

Seeing that dust is constantly being produced during the transit of coal, there is always fine dust floating in the air mixed with moisture, much too small in quantity to produce the most explosive condition, and yet this dust is the most dangerous of any, and may be said to correspond with the dust which, having been left in the pit for upwards of ¾ hour after being thrown in,

* *Minutes of Evidence taken before the Royal Commission on Explosions from Coal-dust in Mines; with Appendices and Index*, vol. ii., 1894, appendix xv., diagram *d*.

was exploded by Mr. H. Hall in more than one experiment. No percentage of moisture, under 5 per cent., can offer any restraint against the extension of a coal-dust explosion* and it is not surprising, therefore, that in the disasters at Tylorstown, Universal and MacLaren collieries, the flame swept along the watered parts of the roads as if they were charged with gas. Experiments made in Germany, entirely support these facts, as it was there proved that water had no restraining influence on an explosion of coal-dust, unless the dust was so wet, that water could be squeezed out of it by the hand.† It is useless, therefore, to depend on water-sprays for restraining the extension of an explosion after it has once been initiated.

Water-sprays are to some extent a sanitary requirement, but even from this standpoint can be overdone, and may become the means of extending the horrible disease known as ankylostomiasis. This is not a "bogey" to be lightly considered, but a serious matter: thus Dr. J. S. Haldane states that "it is evident that the spread of the disease may be entirely checked by preventing the pollution of mines by human excrement. Unless this is effected, as it certainly can be, the disease will probably spread gradually throughout the mines of England, wherever the temperature and moisture are favourable to the growth of the larvæ."‡ As damp and warm air is favourable to the propagation of ankylostomiasis, the writer would ask Dr. Haldane, or any other authority, what weight of moisture is permissible per cubic foot of air at certain temperatures, to enable colliers to work under the most favourable sanitary conditions. In 1899, there were 94 cases of ankylostomiasis reported in the Westphalian coal-field; in 1900, when water-spraying was made compulsory, the numbers increased; in 1901 there were 1,030 cases; up to October, 1902, 1,355 cases; and the increase continued, until at three collieries, 90 per cent. of the men were said to have been effected; but the disease was checked in 1903, and the percentage of men affected commenced to decrease. One means used for checking its extension was drier air, and, therefore, the Government Mining Board of Dortmund has sanctioned the temporary suspension of compulsory water-spraying. A

* "The Rate of Explosions in Gases," by Prof. H. B. Dixon, *Trans. Inst. M.E.*, 1892, vol. iii., page 317.

† *Trans. Inst. M.E.*, 1893, vol. iv., page 660; and vol. v., page 544.

‡ *Report to the Secretary of State for the Home Department on an Outbreak of Ankylostomiasis in a Cornish Mine*, by Dr. J. S. Haldane, 1902, page 6.

Royal order in the Dortmund district also directs that, if the pit-water is not taken direct from the marl, it must not be used for spraying coal-dust.

The necessity for a full and dispassionate discussion of this subject is evidenced in other ways; thus it has been proved, in evidence given before the Royal Commission on Coal-supplies, that in the deep and hot collieries of this country, in Lancashire and Staffordshire, and in Scotland, water-spraying or other means of damping the air has had to be entirely abandoned, because warm damp air is so enervating that the colliers cannot do their work with any degree of comfort. Here, then, those who hold that watering of some sort is a necessary condition to ensure safety in dusty mines are confronted with a problem, for which at present there is no practical solution. Not only so, but owners, agents and managers of mines are placed in a serious position, for if an explosion occurs in a deep pit, where no watering is practised, H.M. inspectors of mines may, at once, assert that the colliery was not fitted with watering apparatus, and, therefore, that the management had been culpably negligent. And if the opposite extreme be taken, namely, of a colliery so situated that there is a great difficulty in keeping down the formation of ice on the main haulage-ways (No. 3 colliery of Tables I. and II.), and where watering is therefore an impossibility in winter, and even if it were possible, the grains of water that would bring it up to the point of saturation are so few (say 2·6), that although this mine has been described as a dusty and gaseous one, 2·6 grains of water would have to represent the factor of safety. Comparing this case with a deep pit, or say with the Universal colliery, where the air was carrying 4·4 grains of water at or near the pit-bottom, the time seems to have arrived when it ought to be authoritatively stated (1) what is the point of saturation to which air ought to be brought, and (2) how that saturation may be attained.

In summing up the contrary interests involved in the damping of the air in coal-mines, the following questions may be asked: (*a*) Shall we attempt by spraying the impossible task of limiting a possible explosion? or (*b*) shall we give attention to the comfort and health of underground labour, and reduce spraying to a sanitary point?

The Chairman (Mr. W. C. Blackett) drew attention to oily preparations, such as "westrumite," which were now employed for watering the roads and highways, and suggested that, in the discussion upon this paper the members would criticise his proposal that these should be tried in mines. The dust would be laid, and certainly trouble from ankylostomiasis would be avoided, but other questions might arise as to safety.

Mr. J. B. Atkinson (H.M. Inspector of Mines) said that the subject of watering in mines might be looked at from two points of view: (1) Damping in the case of firing shots, that is, the effectual application of water in the immediate vicinity of the shot, about which there was no difficulty; and (2) the general damping of the roads, which was a much more difficult matter. The writer appeared to think that moisture in air itself was a source of safety, but he (Mr. Atkinson) did not know that this view was correct. If the air of a mine was so damp that it exerted a perceptible damping influence upon coal-dust, this made for safety; but the moisture, always present in the air, when it had not that effect, would be useless in preventing an explosion. The suggestion that oil should be used on roads for laying dust seemed a rather objectionable method of dealing with the difficulty. The addition of salt to the water would probably be more appropriate. With regard to the damping of the air in deep and dry mines, to a sufficient extent to deal thoroughly with the dust danger, he did not think that it had ever been thoroughly tested. One method that had been suggested was to send the air into the mine considerably above the normal temperature of the mine and saturated with moisture, so that the air-current would deposit moisture as it went around the workings. This method might be made use of at intervals, and not during the whole time that the pit was working.

Mr. T. E. Forster said that he was inclined to agree with Mr. Atkinson that damping the air was of very little use, unless the roads were thoroughly watered. This was the only method of laying dust, though perhaps it might not be necessary to do it very frequently. He believed that ammonite was used when Mr. Hall made his experiments in the shaft, but he did not quite understand what explosive was used in the other experiments.

The CHAIRMAN (Mr. W. C. Blackett) said that gunpowder was used thrice, with the result that there were three successive explosions; then ammonite was used, followed by roburite, without explosion; then gunpowder was again used, and an explosion resulted. He supposed that the object of the writer was to prove that the use of safety-explosives was better than watering.

Prof. HENRY LOUIS said he had either failed to apprehend the meaning of the writer, or that gentleman was under a misapprehension, for he seemed to base his ideas as to the moisture of the air on observations of wet-bulb and dry-bulb thermometers. So far as he (Prof. Louis) understood the question, wet-bulb and dry-bulb thermometers could only indicate the amount of moisture present in the air as a gas, and not that in the liquid state, and thus did not indicate whether air was dry or moist in the ordinary acceptation of the words; and whereas Mr. Ashworth appeared to imagine that water in the state of vapour could possibly have a restraining effect with regard to explosions, he (Prof. Louis) was not inclined to agree with this view. If the flame of an explosion struck water as a fluid in suspension, it would be rapidly evaporated, an enormous amount of heat would be absorbed, and the flame would be cooled below the firing-point. If they had water in the air in the form of vapour that reduction of the temperature of the flame could not take place. He did not see how the quantity of gasiform moisture in the air, as indicated by wet-bulb and dry-bulb thermometers, could give any indication of its power to stop an explosion.

Mr. H. W. G. HALBAUM said that he had had some little conversation about the question with the writer of the paper, and could say that his view, which he believed was correct to some extent, was that a little moisture facilitated chemical action. For instance, he supposed that, in trying to explode a mixture of oxygen and hydrogen by an electric spark, no explosion would take place if the two gases were perfectly dry; but, if a little moisture were added to the mixture, an explosion would at once ensue on the passage of the electric spark.

Prof. LOUIS said that in most exact chemical experiments it was possible to get oxygen and hydrogen so dry that they could

not be ignited by an electric spark. Such a result could only be obtained in very delicate experiments, and the ordinary air of everyday life contained a relatively-large amount of moisture.

The CHAIRMAN (Mr. W. C. Blackett) said that he had always regarded the watering of mines as preventing the formation of what he had previously termed the "pioneering phenomena," which had to precede the heat-wave following an explosion. It seemed to him that they wanted to take an everyday view that the water was there to lay the dust, and not to prevent any chemical combination with the dust when the explosion had once taken place or begun. Their object was to prevent the explosion, and not to minimize the phenomenon, after it had once started.

Mr. J. P. KIRKUP said that the deeper they went into the earth, the higher they found the temperature, and the greater the amount of water absorbed by the heated air. The human factor would also enter wherever very high temperatures prevailed. Anyone, who had had any experience of mines with temperatures of 90° to 96° Fahr., with the air laden with moisture, must have realized its intolerable oppressiveness. This question would have to be considered in the watering of hot, deep mines, because men would absolutely refuse to work therein.

Mr. C. H. MERIVALE said that, in some Belgian mines, the use of water for the purpose of cooling the air had been abandoned, in order that the perspiration of the men's bodies might be freely absorbed by the air.

The CHAIRMAN hoped that the members would not forget his suggestion as to oil-spraying. He proposed to make a trial, and if oil-spraying laid the dust, one evil was gone, while if it had a smell it would be a healthy one.

Mr. M. WALTON BROWN said that, at his suggestion, some experiments had been made with dust-laying liquids in a mine, and were still being continued.

Mr. JAMES ASHWORTH, replying to the discussion, wrote that Mr. J. B. Atkinson and Prof. Henry Louis were in error in thinking that he "appeared to think that moisture in air itself

was a source of safety," because he was of precisely the opposite opinion. In reply to Mr. Blackett, the quotations from the report of Mr. Hall's experiments showed that a pioneering cloud of dust was not necessary for the propagation of a coal-dust explosion. He (Mr. Ashworth) would like to know how Prof. Louis proposed to ascertain the amount of moisture in the air, if he did not use wet-bulb and dry-bulb thermometers. Water in a finely-divided liquid state could only carry as such, in the air, for a certain distance from each spray, as was very clearly shown in Mr. H. W. Martin's experiments,* and, therefore, the possible restraining effect of water-sprays against the propagation of an explosion, was confined to a certain distance from any one active spray, and beyond that point to the moisture present in the air, which Prof. Louis regarded as "gas." His (Mr. Ashworth's) concluding queries were unanswered, excepting by Messrs. J. P. Kirkup and C. H. Merivale, who agreed with the argument that dry air is a positive necessity in deep mines, and therefore in dusty mines.

The CHAIRMAN (Mr. W. C. Blackett) moved a vote of thanks to Mr. Ashworth for his paper.

Mr. J. B. ATKINSON seconded the resolution, which was approved.

DISCUSSION OF DR. G. P. LISHMAN'S "NOTES ON SAFETY-LAMP OILS."†

Mr. J. B. ATKINSON (H.M. Inspector of Mines) wrote that he would like to know:—(1) When mineral colza oil, with a flash-point of 240° to 260° Fahr., was mixed with vegetable oil, why did the mixture not retain the flash-point of the mineral oil? In distilling Scotch crude-oil, the various oils came off in the order of their volatility, and this method was used for separating them. (2) In what class of pits would it be unsafe to use an oil flashing at 240° to 260° Fahr.? (3) Could not the danger arising from the low flash-point of the oil used be met by increasing the length of the wick-tube? The general impression

* *Minutes of Evidence taken before the Royal Commission on Explosions from Coal-dust in Mines: with Appendices and Index*, vol. ii., 1894, page 26, question 5,382, and appendix xv.

† *Trans. Inst. M.E.*, 1904, vol. xxviii., page 338.

left by Dr. Lishman's paper was, that with mineral colza alone less oil was consumed for a greater amount of light than with any mixture, and that it was the cheapest light. The objections being:—(1) The low flash-point, and (2) as so little of the wick required to be clear of the wick-tube, the light was apt to be easily extinguished.

Dr. G. P. Lishman wrote that mineral colza, in admixture with vegetable or other oil of higher flash-point than itself, suffers a reduction of vapour-pressure, which is directly proportional to the amount of vegetable oil present, and this leads to the higher flash-point of mixtures. Cotton oil has a flash-point of 445° Fahr.; if a mixture were made containing only 1 per cent. of mineral colza it would probably flash nearer 400° than 250° Fahr. The statement that, in distilling crude oil, the various oils came over in the order of their volatility was only approximately true, as the lightest (which came over first) were contaminated with the heaviest, and many distillations were required before a pure substance was obtained.

An oil flashing at 250° Fahr. should not be used in any pit where the lamp-bottom was liable to become too hot to be held in the hand. Most people could not hold anything hotter than 200° Fahr., and at this temperature very little inflammable vapour was given off from mineral colza. Where the oil might become hotter than this, he did not think that any length of wick-pipe would make it absolutely safe. In a case like this, the flash-point of the oil should be raised to about 280° Fahr. by taking a mixture of about 25 to 30 per cent. of mineral colza and the remainder rape oil; cotton oil would not do in this case, as it would certainly separate stearin. When using mineral colza alone, the length of the wick-pipe ought always to be increased and its fit improved, not only for safety's sake, but to prevent the light from being jerked out. The main conclusion to be drawn from his paper was that the best possible oil for safety-lamps should not cost more than £12 per ton, or less than that when mineral colza was lower in price.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT, JANUARY 9TH, 1905.

THE PRESIDENT (MR. A. H. HEATH, M.P.), IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentleman, having been previously nominated, was elected:—

MEMBER—

Mr. I. G. BRUNT, Upper Market Square, Hanley.

Prof. T. TURNER read the following paper on "The Development of Higher Education in North Staffordshire":—

THE DEVELOPMENT OF HIGHER EDUCATION IN NORTH STAFFORDSHIRE.

By THOMAS TURNER.

The need for greater attention to, and increased facilities for, higher education in Great Britain is now recognized by all thoughtful observers. In recent years, great advances have been made, among the most striking being the work of local authorities in intermediate education, and the development of the modern university. Other countries are not standing still, and both as regards total provision, and supply in proportion to population, there is much leeway to make up before our competitors can be met on equal terms. In this country, higher education has been influenced and developed along two main directions: (1) By the older universities acting from the top downwards, and through secondary schools, examinations, scholarships, and the extension-movement, guiding and assisting those who required higher training. (2) By local effort and enthusiasm, acting from below upwards, and leading to ever-widening and increasing effort.

The modern university, such as those now existing at Birmingham, Leeds, Liverpool and Manchester, is the result of this upward movement. The real foundations of the movement may be traced in national schools, night schools, Sunday schools, and the ragged schools of a century ago. From this basis, came a generation which could originate and appreciate working-men's institutes, literary and debating societies, and other means of further education. The work of the college did not interfere with, but rather stimulated, the progress of evening classes. The ever-rising, ever-widening character of such work led to the foundation of the Birmingham University in 1900, after £400,000 had been raised by voluntary contributions.

There is a time in the educational history of every important district, when the progress which has already been made renders

a further important step absolutely necessary, if that progress is not to be retarded or absolutely checked. The Pottery district has now reached that point, and is at the parting of the ways. A generation ago, the art classes of the Potteries were famous throughout the country. Science classes have been held with varying success, while with the aid of the County Council large numbers of students have been trained in technology—including mining, metallurgy and pottery. There were 384 students in attendance at the mining classes in North Staffordshire during the session 1903-1904. Some 4,000 or 5,000 persons are attending classes in different subjects at the various institutes throughout the Potteries. There is thus a large body of partially-educated students in the district who are cut off geographically from any centre of higher learning, and who cannot get all they need at any of the existing schools in the neighbourhood.

The only practicable scheme before the public is that of the Council for the Extension of Higher Education in North Staffordshire. The formation of this body, its successful extension-work, and the munificent gift, by the late Mr. A. S. Bolton, of a site close to the station at Stoke-upon-Trent, are matters of recent local history familiar to all. The real questions are:—(1) Can a scheme be devised which shall be satisfactory alike on educational and financial lines to both the County Council and the Council for Higher Education? (2) Is the scheme such as will obtain the moral and financial support of the inhabitants of the district?

These points may be considered in order, namely:—(*a*) The educational scheme; (*b*) the financial basis; and (*c*) the support from the district.

(*a*) It is evident that anything in the way of a modern university for North Staffordshire is out of the question. All that can be aimed at is a college affiliated with some university outside the district; and it would be some time before the college would be in a position even to apply for affiliation. The new institution would have to serve two primary objects, at first sight antagonistic but happily reconcilable: that is, to supply instruction in humanistic or culture subjects, and also to provide the instruction required for the proper conduct of the staple industries of the district. The industries demand instruction in

mining, metallurgy and ceramics. The two sides would be linked together by subjects such as mathematics, physics, geology and chemistry, which are more or less common to both. By arranging for these three sides, the college would meet the needs, and might reasonably anticipate the support of three important interests, the County Council, the manufacturers and the public. The training of pupil teachers would not form a part of the regular work of such a college, but a pupil teachers' centre might, with advantage, be conducted in connection with the normal department.

(*b*) The admirably suitable site provided by Mr. A. S. Bolton solves the preliminary financial difficulty of the undertaking. Some years ago, £25,000 was estimated as the minimum required for suitable buildings. The part required for teachers and for pupil teachers the County Council might provide. It might also provide part of the cost of the technological, science and administrative sections. The manufacturers and the general public might reasonably be expected to contribute a considerable proportion of these latter costs. The County Council might be expected to contribute to the maintenance of the college, by defraying the cost of the training of teachers, either directly by grants: or less directly by capitation-payments. From the same source, the college might receive assistance equal to the money now spent in teaching, apparatus and materials for the technological classes of the district. An endowment fund would be required, and should be started as soon as possible, while annual contributions would be necessary to provide the deficiency. As the college became established, it might hope to participate in Government grants.

(*c*) If the college is to achieve any real success, it must receive the hearty support of the residents in the neighbourhood, such as has been shown in similar cases elsewhere. In North Staffordshire, if the County Council are to be asked to make their centre on the site at Stoke, it is evident that some return will be expected; otherwise, it would pay the County Council to erect the building in their own area, and save the local rates. On the other hand, there are to be reckoned the site, the local contributions, and the help and support of men of special experience in local requirements. In arranging for the governing body of the college, an opportunity should be taken to enlist the help and

sympathy of as many willing helpers as possible, and to provide that those who are prepared to contribute freely to the cost of the institution shall have an interest in its management. The college should not be a County Council, but a public institution, aided by the County Council.

The PRESIDENT (Mr. A. H. Heath) said that the Council of the Institute had that afternoon agreed to select two delegates to represent them at a meeting of the County Council, in order to support the following resolution, which he moved:—That in the opinion of this Institute it is desirable that facilities for higher instruction in mining should be greatly increased, and that the secretary be instructed to write to the county authority urging upon them the necessity of providing such facilities in connection with the proposed North Staffordshire College.

Mr. W. N. ATKINSON seconded the resolution, which was agreed to.

Mr. A. W. BROWN observed, with regard to the management of the proposed college, that it was proposed to have a Board of Governors—with committees for different departments. One would be for the mining department, and its members would be largely selected from representatives of the Institute and colliery owners, so that there need not be any fear that the scheme was one by which the contributory bodies would be neglected. He hoped that the work would bear fruit, and that they might see a college established within the next few years.

The PRESIDENT (Mr. A. H. Heath) said that the whole of the money for the training college for pupil teachers would come out of the public funds; and the Institute would only have to ask for £4,000 for the mining school. The college would be of the greatest possible benefit to everybody interested in the science of mining engineering. He moved a vote of thanks to Prof. Turner for his address.

Mr. W. N. ATKINSON, in seconding the resolution, said that no one could doubt that the mining industry was convinced of the necessity for higher education in the district in scientific subjects, so as to secure efficient management in carrying on

mining and manufactures. When they considered the large population of the district dependent upon certain industries, and the keen competition which was rife in these days, the necessity for such higher education as they were seeking to establish was self-evident. It was the duty of the County Council to provide the means of education required in the county.

Mr. J. T. STOBBS, who supported the resolution, submitted that North Staffordshire was not more apathetic in respect to higher education than other districts in Great Britain. Some progress had been made in North Staffordshire towards establishing a college, although the matter had only been under consideration for a little more than four years.

The vote of thanks to Prof. Turner was cordially approved.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING.

HELD IN THE ROOMS OF THE CHRISTIAN INSTITUTE, GLASGOW, FEBRUARY 9TH, 1905.

MR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

In the absence of the Secretary, Mr. James Hamilton was appointed Secretary *pro tem.*

The minutes of the last General Meeting were read and confirmed.

The following gentleman was elected:—

MEMBER—

Mr. JAMES MCKENZIE, Lanemark Collieries, New Cumnock.

Office-bearers for the session 1905-1906 were nominated, and auditors were appointed to examine the Treasurer's accounts for the past year.

The PRESIDENT (Mr. R. T. Moore) said that a large number of the members had that afternoon paid a visit to Messrs. Mavor & Coulson, Limited's works, where they had seen much to interest them. He moved a vote of thanks to Messrs. Mavor & Coulson, Limited, for giving the members an opportunity of inspecting their works.

DISCUSSION OF MR. ROBERT CRAWFORD'S PAPER ON "WINDING OF MINERALS FROM INCLINED SHAFTS."*

Mr. Robert McLaren (H.M. Inspector of Mines) remarked that, as one who had an opportunity of descending the inclined shaft to note the operation of this machine or carriage, he would like to say that, in his opinion, the carriage was well fitted for inclined shafts. One had a strange feeling in going down some inclined shafts, as there was always a danger, unless certain precautions were taken, of being thrown down the incline. There was great difficulty in some inclined mines, such as shale-mines, in getting a carriage suited to the various grades. He sometimes thought that those who were responsible for the arrangements at the surface forgot that there was a varying grade underground, with the result that, instead of one man being required to put on a tub, it sometimes took two men, and even then accidents had been known to occur. In the carriage which had been described, the centre of gravity was always steady, irrespective of the gradient, and all that was required in the mine was to make the benches level. He found, after examination, that there might be a difficulty with the centre carriage, which might get out of place, with the result that persons might be injured or property damaged. He wás told that they had never any difficulty in this connection at Loanhead, and that there had never been a wreck. He was disposed to think that there was a defect, in this respect that if the bottom carriage were to leave the rails, or the top carriage to jump the radius rail, there might be a serious accident. Members, however, who used inclined shafts running from the surface at high gradients, could not do better than adopt a carriage of the same type as that described.

Looking at the machine from the point of view of an inspector of mines, he thought that it was a very safe arrangement; but, after all, he preferred a perpendicular shaft. It might be used with profit in regard to loading and unloading, at some of the shale-mines where an older system was in operation. It was true that in many of the shale-mines the gradient was as high as 1 in 1 and as low as 1 in 7, and to have a carriage that would suit all these varying gradients was believed to be an impossibility.

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 230.

Mr. R. Crawford said that, before reading the paper, he had visited a few inclined mines, and found in each case that the detrimental point with regard to the time of the wind lay not in the winding, but in the changing of the tubs. In one case, where the depth of the incline was 1,620 feet on the slope, and using a carriage with two fixed decks, with two tubs on each deck, 60 per cent. of the time of the wind was consumed in the changing of the tubs. In another instance, where the depth of the incline was 1,800 feet, and using a carriage with six fixed decks, with one tub on each deck, 67 per cent. of the time of the wind was occupied in the changing of the tubs. These results were even more satisfactory than those obtained with the obsolete arrangement at Burghlee, where 75 per cent. of the time of the wind was occupied in changing the tubs. Yet they were very far from what would be recognized as satisfactory results, when compared with the time to change the tubs at a perpendicular shaft. In his (Mr. Crawford's) opinion, the important point in winding from inclined mines was the efficient equipment of the winding plant, with a view to the rapid changing of the tubs: and he had no doubt whatever that the system which he had brought before the notice of the members would present itself to their minds as possessing indisputable advantages in that direction, as compared with systems in vogue, similar to those mentioned, where two or more fixed decks required to be changed per wind at one common landing. Lately, even better results had been obtained with the arrangement than those stated in his paper, only 21 per cent. of the time of the wind being required to change the tubs. This was equivalent to the time occupied at a perpendicular shaft in changing the tubs. As to the defect in the arrangement of the carriage, which Mr. McLaren had mentioned—that of the derailing of the movable decks from their curved tracks should the carriage receive a heavy shock—as, for instance, when the carriage became derailed when running at a high speed, he thought that could easily be remedied by fixing along the inside of each curved rail a piece of angle-iron to act as a guide-rail to the movable deck, but up to the present time guide-rails had not been required, as the carriage acted satisfactorily in every respect.

The President (Mr. R. T. Moore) remarked that with an inclined mine, such as that at Loanhead, the great difficulty was

in winding the material; and if the improved appliance, described by Mr. Crawford, enabled 500 or 600 tons a day to be drawn, it certainly overcame many of the objections which were urged against them. The carriage was an ingenious arrangement, and seemed well suited for its purpose. He was satisfied that the members were indebted to Mr. Crawford for bringing this matter before them, and their cordial thanks were due to him for his paper.

DISCUSSION OF MR. JAMES RODEN'S PAPER ON "COAL-MINING IN BORNEO."*

Mr. ANDREW BURT (Tranent) wrote that he was somewhat surprised to see from Mr. Roden's paper that the average temperature in Sarawak at night was 85° and during the day 120° Fahr. in the shade. During a visit to British North Borneo in the summer of 1903, the temperature did not touch 90° Fahr. in the shade, and, from the reports of the managers of the tobacco-plantations, the average minimum was 75° and the average maximum 95° Fahr. In the north-eastern and eastern districts of Borneo the evenings were cool, and a blanket was invariably required at night. In the early morning, walking through the jungle or driving in the open, one felt a sharpness in the air which was very bracing. Only twice had the writer had experience of a temperature exceeding 110° Fahr. in the shade during a six years' stay in the East; that was in the summer of 1898, in Pekin, when the thermometer touched 112° for a few days, and again in 1902 at a small town in Szechuen (in Western China) when it attained 115° Fahr.

The labour-question was a very important one, especially in the tropics, but from the scale of wages given by Mr. Roden, the colliery-owner did not seem to get full value for his money. From experience, he (Mr. Burt) found that the best and cheapest work was done by contract. Chinese were born contractors. In the mines in China, a contractor took a section and supplied a number of men, these he fed and housed, deducting a certain sum from their earnings for food, etc. Working in this way, the average tonnage-rate in a coal-seam, 5 feet thick, on an

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 236.

inclination of 45 to 90 degrees from the horizontal, worked stoop-and-room, was 15 cents for round coal and 7 cents for dross. A dollar or 100 cents was worth 2s. The stoops were worked at the same price, and this included, hewing, filling and drawing a distance up to 1,000 feet. In the flat workings in the Yangtsze valley, the average price for a seam, 5 feet thick, was 13 cents for round coal and 6 cents for dross, but this rate did not include brushing. Day-labourers, or shiftmen, were paid 6 and 7 dollars per month of 28 days, and overmen or deputies, from 15 dollars upwards.

Mr. J. Fordyce Balfour had stated that Malays made the best miners in Sumatra and that Chinese labour was used on oncost work, whereas Mr. Roden stated the opposite as being the case in Borneo. During his (Mr. Burt's) short stay in Labuan he paid a visit to the mines at Coal Point, and the manager (Mr. W. Hopwood) expressed the opinion that Malays would make better miners than Chinese, who had been most in evidence previously, and stated that he intended to make the experiment. Could Mr. Roden give any information as to this experiment? Chinese, if properly handled, made good workmen, and not a few of them could compare favourably with some of the miners in this country.

Mr. R. W. Dron said that he was consulted regarding the Labuan coal-field about eight or ten years ago. He found that the miner's darg was about 12 cwts. per day and he imagined then that, if they had had the same circumstances in Scotland, it would be equal to a darg of 2 tons 10 cwts. Although the miners were getting a low rate of wages, they were correspondingly less efficient. The system of working was by numerous inclined shafts from the surface, but he believed that since the time of which he was speaking a vertical shaft had been sunk and the mine had been wrought in a more systematic way.

Mr. James Hamilton said that Mr. Roden stated that "there has evidently been great disturbance of the earth's crust, as the seam, at this particular part of the field, has, apparently, been reversed." Is there any other evidence of this than that the seam has a fire-clay roof and a sandstone pavement? The occurrence of the seam in part of the field, at an inclination of 15 degrees, is strong evidence against such a reversal.

Mr. JAMES S. DIXON said that, in a country where the temperature was about 100° Fahr. on the surface, it would be highly interesting to get particulars of the underground temperatures, say, from 50 feet downwards.

Mr. T. H. MOTTRAM asked how many seams of coal were being worked at Sadong, and whether the prices paid to miners applied to all the seams described or to one only.

Mr. J. RODEN said that only one seam, 3 feet thick, was now being worked at the Sadong mines.

Mr. R. McLAREN asked whether it was not possible for the thin seams to have been wrought by the longwall method and what were the difficulties, if any, which prevented the adoption of that system. He noticed that the stoop-and-room system was generally in vogue. He asked what system of ventilation was used in Borneo. He agreed with Mr. Dixon that it would have been most interesting if some data had been given in reference to underground temperatures. He noticed that in a seam, 3 feet thick, Chinese miners in Borneo could turn out a daily darg of 3½ cwts. to 4½ cwts. a day.

Mr. THOMAS THOMSON (Hamilton) thought that mine-owners in Borneo were not paying more for the production of their coal than the owners did in Scotland. He understood from Mr. Roden's paper that the daily output for every person employed at the colliery (including miners, drawers, pithead workers, clerks, tradesmen, etc.) was 4½ cwts. The wages paid to these people was not given, but supposing that they were paid the same as the miner, namely, 1s. 0½d. per day, the cost of the coal would be about 2¾d. per cwt.; and he thought that many collieries in Scotland were not producing coal at a lower cost than 2¾d. per cwt.

Mr. J. RODEN said that the output was equal to 4½ cwts. per man employed at the Labuan colliery, and the cost was 1s. 0½d. for 12 cwts. or 1d. per cwt., while in Scotland, the miner's cost was 5s. 6d. per day for 40 cwts. or 1·65d. per cwt. The longwall system was applied to the working of the thin seams at the Sadong colliery. At Brooketon, where the coal was very thick, and where it was lying at a high inclination, he thought that the

system, in vogue while he was there, was the best that could have been adopted under the circumstances. As evidence of the heavy rainfall, he might say that on one occasion, in the course of 24 hours there was a rainfall of 26½ inches. In the Brooketon coal-field, the seams had apparently been reversed, as the roof was a thin layer of fire-clay, overlain by a more or less thick bed of blue till. He could assure Mr. Dron that while he was at the Labuan colliery, 97 per cent. of the miners were Chinese; and at Brooketon colliery, the percentage was about 99. Malays were indifferent workers, and did not like digging coal. The Chinese miners were all imported.

The PRESIDENT (Mr. R. T. Moore) declared the discussion closed, and a hearty vote of thanks was passed to Mr. Roden.

Mr. E. O. FORSTER BROWN then read the following "Notes on the Application of Electric Power at Mines in Germany":—

NOTES ON THE APPLICATION OF ELECTRIC POWER AT MINES IN GERMANY.

By E. O. FORSTER BROWN.

Introduction.—The principal coal-mining districts of Germany are Westphalia, Silesia and Alsace-Lorraine, with yearly outputs of approximately 60,000,000, 25,000,000 and 12,000,000 tons of coal respectively: the last-named is chiefly owned and worked by the State.

Westphalia has of late made the greatest strides in experimenting with, and applying, electricity in various ways for mining purposes, although the natural conditions prevailing there appear to be scarcely so favourable for its adoption as in Silesia. In Silesia, the seams are not very deep; accordingly there are more shafts and greater scope for reducing the cost of several separate boiler-plants by transmitting electricity from a main central station to work the machinery at the outlying shafts. Inflammable gas does not occur in the seams at present being worked, and there is less risk in transmitting current and employing electrical machinery underground. The coal used for the boilers, however, is of very little value, and is often unsaleable. In Westphalia, on the other hand, the seams are fiery, but boiler-coal is of much greater value than in Silesia, so that any saving of power is an important economy; and there is also probably more capital available for expenditure on new plant in that district. The majority of the State-mines in Alsace-Lorraine are old, and, up to the present time, electricity for power-purposes has not been applied to any large extent. On the other hand, the Saar-Mosel Company, operating in the same coal-field, has laid out, and nearly completed, a very extensive and modern installation.

The system of current used for general purposes at all of the newer plants is with rare exceptions three-phase. The chief advantages of this system over continuous current are

that three-phase machinery is cheaper to construct; it admits of being generated and transmitted at a high voltage, at a relatively smaller cable-cost; it can be transformed to any suitable working voltage in the neighbourhood of the motor; and the absence of a commutator on the motor considerably simplifies the working and attention required. Its chief disadvantage for economical working arises where regulation in the speed of a motor is required, as a regulator has not yet been invented which will do more than consume the surplus-current beyond that required for the speed at which the motor is running; accordingly the same amount of current is required for a motor running at half-load as at full-load: the surplus being wasted in the regulator as heat. A shunt-circuit continuous-current motor, on the other hand, can be regulated with very little loss of efficiency.

The central power-houses of the newer plants are well built and roomy, and fitted up in some instances on a most lavish scale. In addition to the generators, they usually contain the air-compressors and, sometimes, the ventilating-fan engines. The generators are driven by tandem or cross-compound condensing horizontal steam-engines, with steam at a pressure of from 100 pounds to 180 pounds per square inch. At coking collieries, there is a tendency to take the gas from the ovens, and after purification it is used to generate electricity direct by means of gas-engines: the saving of power by this method over that of burning the gas under boilers and generating electricity by the steam so raised being rather more than doubled. Up to the present time, however, the unreliability of gas-engines has presented difficulties to the general adoption of this arrangement.

The voltage used naturally varies very much with the conditions; for three-phase current it is not, as a rule, less than 1,000 volts, it is usually 2,000 or 3,000 volts, and sometimes 5,000 volts; and, in the majority of cases, it is transformed down to 200 or 300 volts at the motor. The pressure of continuous current does not, as a rule, exceed 500 volts.

The purposes to which electricity is chiefly applied may be stated roughly, in their relative importance, as:—Pumping, ventilation, winding, haulage, coal-cutting and air-compressing.

A large variety of electrically-driven pumps are employed: the tendency in plunger-pumps being to increase the speed to

the utmost limit of practicability, to drive with comparatively large, slow-running motors, and so eliminate the use of gearing. The pump of the future, however, appears to be of centrifugal type. Some of the advantages of this pump over plunger-pumps are as follows:—It costs less for the same capacity, it occupies less space, requires less attention, lubrication and repair; and it is particularly suited for driving by electricity, as both the pump and the motor give the best results when running at a high speed. The efficiency is not quite so high as in the case of plunger-pumps, but this point can scarcely counterbalance the advantages enumerated. Centrifugal pumps are already extensively used for high as well as low lifts. They appear to give excellent results for sinking purposes. The pump and the motor lying above it are fixed together in a vertical frame, which is hung from the surface by ropes and raised or lowered in the sinking shaft as required, the motor-cable being correspondingly coiled or uncoiled from above.

In practically all cases, where electricity is applied for power-purposes, the ventilating fans are driven by motors, sometimes by belts and sometimes direct on the same shaft, the fans being of a variety of makes, but chiefly Rateau, Capell and Guibal. An instance of the attention required for one of these electrically-driven fans is significant, in comparison with that required for a steam-driven fan of equal capacity. The Rateau fan in question, at an isolated ventilating shaft belonging to the Saar-Mosel Colliery Company, displaces 110,000 cubic feet of air per minute, and is driven by a three-phase motor of 5,000 volts, keyed direct on the fan-shaft, running at 300 revolutions a minute. The door of the ventilator-house is kept locked; every three weeks the motor is cleaned, which takes 2 hours, and every three months fresh oil is put into the bearing-cups, otherwise no one goes near the house. The fan has been running satisfactorily and continuously for a year under these conditions.

Winding-engines of high power have only lately been erected at one or two collieries, but a number of smaller engines, chiefly constructed on the Ilgner principle, are working at subsidiary shafts, where they are mainly used for lowering men and material. Electrical power is extensively applied for haulage-purposes, and sometimes for compressing air at a considerable distance inbye from the pit-bottom.

A few details of electrical plant at some of the collieries, visited by the writer, will serve to illustrate the foregoing remarks.

Donnersmarckhütte Colliery, Silesia.—The power-plant is capable of producing 1,060 kilowatts of continuous current at 230 volts, and 2,800 kilowatts of three-phase current at 1,000 volts, a total of 3,860 kilowatts. Two-thirds of this output is generated by gas-engines, supplied with gas from the blast-furnaces, belonging to the colliery, and the remainder by horizontal tandem compound-condensing steam-engines. The current at 1,000 volts is transmitted to a distance of 3 miles. Electrical power is applied to pit pumps, sinking pumps, ventilators, and hauling- and winding-gear. The centrifugal sinking pump is constructed and hung in the shaft in the manner before described; it is at present pumping 400 gallons to a height of 460 feet (140 metres), and the motor is supplied with current at a pressure of 1,000 volts. The electric winding-engine, constructed on the Ilgner principle, is of 125 horsepower.

Preussen Colliery, Silesia.—This colliery is not yet completed and the shafts are still being sunk. Electricity is used for most power-purposes, with the exception of winding. The generating-station at present contains two three-phase dynamos of 450 kilowatts at 3,000 volts, and one three-phase dynamo of 450 kilowatts at 500 volts.

The pumps in use for sinking and pumping from the lodge-rooms consist of the following: One centrifugal sinking pump hung in the shaft, and pumping 330 gallons a minute to a height of 279 feet (85 metres). The pump, in two steps, revolves at 1,450 revolutions a minute and is driven by a motor with current at 500 volts. No. 1 lodge-room contains two high-pressure centrifugal pumps, each horizontal, in two parts with two steps in each part, and a motor between the parts. Each pump can pump 1,100 gallons per minute to a height of 689 feet (210 metres). The motors run at 1,420 revolutions a minute with current at 3,000 volts. The No. 2 lodge-room contains a plunger-pump, driven direct by the motor without gearing, and pumping 345 gallons a minute to a height of 525 feet (160 metres). The motor runs at 200 revolutions a minute with current at 500 volts.

Court Colliery, Westphalia.—At this colliery there are two three-phase generators capable of producing 550 kilowatts each at 2,000 volts, driven by cross-compound steam-engines with steam at a pressure of 100 pounds per square inch.

Electricity is applied at the surface for the ventilation of the mine and most other purposes, with the exception of winding. Underground, 31 motors are employed. These work 18 small winding-engines each of 25 horsepower, an air-compressor of 75 horsepower supplying air to rock-drills, 5 hauling-engines, a centrifugal pump, and 6 small ventilators, an aggregate of 747 horsepower. Except in the case of two haulage-motors of 60 horsepower and 75 horsepower respectively, wound for 2,000 volts, the voltage is transformed to 215 volts at the various motors: each motor having a separate transformer. The motors for the small winding-engines run at 960 revolutions a minute, and are geared down to the drums, so that the latter wind at the rate of 3¼ feet (1 metre) per second, with a load of one ton. The starting- and reversing-switch lever and the brake lever of these engines are arranged so that the current cannot be switched on unless the brake is off. A small amount of gas is given off, the air in the upcast shaft containing about 0·10 per cent.

Alten Essen Colliery, Westphalia.—The new power-station, lately erected and expected to start working shortly, contains a compound tandem horizontal steam-engine, arranged to drive either a direct-current dynamo of 500 volts and 500 horsepower, or a three-phase dynamo of 5,000 volts and 500 horsepower: the generators being placed on opposite sides of the main shaft. A double-acting Körting gas-engine, to be supplied with gas from the coke-ovens, will drive a direct-current dynamo of 500 horsepower at 500 volts. The gas will be taken from Otto Hilgenstock bye-product coke-ovens.

The chief purpose to which electricity is applied is that of driving a large washery, the amount of regulation required for driving the different parts, rendering the adoption of direct-current shunt-wound motors particularly suitable for this purpose.

Victor Colliery, Rauxel, Westphalia.—The generating-plant consists of a horizontal cross-compound condensing steam-engine, with a high-pressure cylinder, 30 inches in diameter, and a low-pressure cylinder, 49 inches in diameter by 3¾ feet stroke,

supplied with steam at a pressure of 110 pounds per square inch. This engine drives a three-phase dynamo at 112 revolutions a minute; and the current is transmitted at 5,000 volts to a centrifugal pump at the pit-bottom, over 1,640 feet (500 metres) from the surface.

The centrifugal pump is of the Sülzer type in two parts, each part is in four steps and is driven by a separate motor; the first pump sucks the water from a depth of 13 feet (4 metres), and delivers it to the second part at half the velocity required for the total lift; and the second part supplies the remaining velocity required. The motors, of 600 horsepower each, are keyed on the same shaft as their respective pumps, and run at 1,035 revolutions a minute. The total vertical lift exceeds 1,640 feet (500 metres), and the total quantity of water pumped is 1,540 gallons per minute. As the generating-plant only drives the pump, the motors of the latter do not require to be switched on underground, but start working with the steam-engine at the surface. From the results of tests made of this pumping plant running under normal conditions, it appears that the efficiency of the pump is 75 per cent., and of the dynamo, cable, motors and pump 60 per cent.

Preussen II. Colliery, Westphalia.—A large electric winding-engine has recently been erected at one of the shafts at this colliery for experimental purposes. The generating-plant for supplying current to drive the winding-engine consists of two cross-compound horizontal steam-engines, with steam at a pressure of 150 pounds per square inch, each driving a three-phase dynamo of 2,000 volts at 86 to 94 revolutions per minute. From 1,550 horsepower downwards is required of the two dynamos at different periods during the wind, but the normal capacity of each engine is 650 horsepower.

The winding-engine, placed in a house close to the generator, winds with a Kœpe pulley, and is driven by a slip-ring motor keyed direct on the same shaft. The present depth of winding is 1,837 feet (560 metres), but it is eventually intended to wind 100 tons per hour from a depth of 2,300 feet (700 metres). The engineman is provided with a lever for starting, reversing and cutting off the current, according as it is in its forward, back, or middle position; he also controls a compressed-air or steam-brake and an emergency foot-brake.

The difficulty of dealing with the large amount of heat generated by the frequent regulation of the motor is overcome by an ingenious water-resistance, connected with the rotor slip-rings, arranged in the following manner:—The cables from the rotor slip-rings terminate in electrode-plates dipping into a small cistern, continually being fed with water by a small electrically-driven centrifugal pump, and fitted with a pair of valves, opening outward, which allow the water to escape from the cistern at two points, either near the extremities or just below the extremities of the electrode-plates. The valves are regulated by the lever before referred to, and the gradual opening or shutting of the valves raises or lowers the height of water in the cistern, and accordingly increases or decreases the immersion of the plates and the resistance in the rotor-circuit. If the pressure during the wind falls to 1,600 volts, an electro-magnetic brake comes into operation, and prevents the coils from being burnt out. The winding-engine appears to be under good control and winds satisfactorily, but the effect of this system on the generator engines is not ideal. Between winds, the generating steam-engines are running at 94 revolutions per minute and with only sufficient steam to overcome the friction of the working parts at that speed; on starting to wind, their full power and something more is required of them, and they take their full steam and lose 7 or 8 revolutions a minute in speed almost instantaneously, gradually regaining their full number of revolutions as the wind proceeds and the demand for power lessens. Near the completion of a wind, full power is usually required in the opposite direction for braking purposes, and the same thing takes place, although the engines are fitted with sensitive governors.

Under such conditions, this type of electric winding-engine is not likely to prove successful, but, on the other hand, if the generating-station were very large and supplied current for a large number of other purposes, the effect of starting the wind would be barely noticeable on the steam-engine driving the generators. In the case of a colliery intended to be worked solely by electric power, it would be of advantage to have a reliable winding-engine capable of being run and controlled by such power, as efficiently as by steam; but it is improbable, however, that any colliery would erect a sufficiently large generating station to satisfy these conditions. An elec-

tric winding-engine driven by three-phase current has the disadvantage, as before stated, that it cannot be so economically regulated as one driven by a continuous-current motor.

Zollern II. Colliery, Westphalia.—An elaborate electric plant has recently been erected at this colliery, the primary power for working the various colliery-engines in all cases originating in the steam-engines driving the generators. Two shunt-excited direct-current dynamos, each of 500 volts and 2,100 ampères, are driven direct by triple compound horizontal steam-engines at 90 revolutions per minute, with steam at a pressure of 176 pounds per square inch. Each dynamo has a flywheel fitted on the same shaft. The interesting characteristic of this plant, in comparing it with others recently erected, is the exclusive use of continuous current and the shunt-regulation of the motors. At present, electricity is not used for power-purposes underground, and only within a very restricted radius on the surface; accordingly, there would probably be no economy in transmission-cost by the adoption of alternating current, although the possibilty of its being required in the future has been foreseen, and the generators are fitted with slip-rings as well as commutators. At any colliery where, as in this case, electricity is applied for all purposes on the surface within a limited radius, including air-compressing, the question of economical regulation of the motors must play a much more important part for successful working, than in the case of a colliery where the same power is chiefly required for driving ventilators and underground pumps, which seldom require speed-regulation and are often placed at a considerable distance from the generating-station.

Two air-compressors, in the same house as the generators, and of the two-stage type, are each driven by a 500 horsepower motor, keyed direct on the main shaft, with speed-regulation of from 75½ to 130 revolutions per minute, and they deliver air at a pressure of 90 pounds per square inch. The cylinders, although water-cooled, owing to the high speed of running, become exceedingly hot, and at 75½ revolutions the air from the high-pressure cylinder has a temperature of 102° Cent. Apart from the question of convenience, the economy of this arrangement appears questionable.

The winding-engine is constructed on the Ilgner system, by

which the fluctuations of power required during winding are averaged by a converter placed between the winding-engine and the generators. The shaft of the converter carries:—(1) The converter-motor, H, with a horsepower equivalent to the average of that required for continuous winding, including pauses between the winds. This motor is driven off the main circuit, and may be wound for taking polyphase, alternating or continuous current. (2) A heavy flywheel, S. (3) A continuous-current dynamo, D. And (4) a small continuous-current dynamo, E (Fig. 1, Plate II.). The winding-drum may be driven by one or two continuous-current motors, according to its size, but the principle is not affected, in the latter case, as both motors are supplied with current from the same source. The winding-motor, F, is driven by the generator, D, the magnets of both D and F being excited by separate connections, M_2 and M_3, from the small dynamo, E. Before winding commences, the converter is run up to a high speed of rotation (600 to 700 revolutions a minute), sufficient current being supplied to H from the mains for this purpose, the same being regulated by the governor, C, and resistance, R. Until winding is commenced, the excitation of the magnets of the generator, D, is switched out so that no current is supplied to the winding-motor, F. The wind is started by moving the starting lever, A, to one side, this operation exciting the magnets of the generator, D, and so sending current in one direction into the winding-motor, F. The power, however, required at starting is considerably more than the converter-motor, H, is wound for producing, and in the ordinary course of events the speed of this motor would fall to nothing in attempting to supply it; this is prevented by the heavy flywheel, S, which, revolving at a high speed, contains sufficient stored-up energy to keep the converter running at a speed little less than normal until the extra demand for power is past. On throwing the lever, A, over to the opposite side, near the end of a wind, the current in the magnets of the generator, D, and accordingly to the commutator of the winding-motor, F, is reversed; and the winding-motor, F, until it stops revolving, acts as a generator to the generator, D, and is braked in an effectual and economical manner. A portion of the power originally given out is thus returned to the converter, and assists the converter-motor, H, in re-accelerating the flywheel up to the full number of revolu-

tions. The engine is very simply controlled by means of the lever, A, for starting, reversing, braking and stopping, and by a compressed-air brake, for holding the engine between the winds. [The diagram illustrates the principle but not the actual arrangement of the electric winder at Zollern II. colliery.]

The details of the control and switch apparatus illustrated in Fig. 2 (Plate II.) are as follow:—A, High-tension switch-box; C, starting switch for converter-motor; E, lever-frame; G, commutator; H, oil dash-pot; F, starting gear; P, lifting arrangement for the safety-brake, with emergency switch; and Q, regulating switch.

The dimensions of the principal parts of the winding-engine at the Zollern II. colliery, are as follow:—(1) The converter, comprizing the continuous-current converter-motor of 300 horsepower at 500 volts, a fly-wheel of solid Krupp nickel-steel, weighing 40 tons, and the converter-dynamo of 900 horsepower at 500 volts. (2) The winding-engine is a Kœpe pulley, fitted with two continuous-current motors, each of 705 horsepower, on the same shaft on each side of it. This winding-engine is at present winding 1,200 tons of coal in 12 hours from a depth of 918 feet (280 metres).

By means of this arrangement, the converter-motor, H, is supplied with an almost constant quantity of power from the main circuit throughout, the flywheel supplying the extra quantity required by the winding-engine at starting, and this again being made up to it before the commencement of the next wind, partly by the converter-motor, H, and partly by the power returned to the flywheel in braking the winding-motor, as already explained. This type of winding-engine, although more costly than the type in use at the Preussen II. colliery, has a great advantage in demanding an almost constant instead of an intermittent load from the generators, at the same time being under very efficient control; on the other hand, the arrangement of the machinery appears at first sight to be rather complicated, and it is at a disadvantage, when used for intermittent winding.

Until electric winding-engines of a large size have been conclusively proved to be as reliable and efficient as steam-engines, and at the same time show a substantial saving in fuel

and upkeep sufficient to repay the original capital outlay, electrical power is not likely to be applied to a large extent at individual collieries not troubled with water, where the winding-engines consume the largest proportion of power required for working the colliery.

RULES.

A special meeting of the Institute then took place to consider the proposed alterations of the Rules, of which due notice had been given.

After discussion, the alterations were adopted without modification as follows:—

Rule 2.—"The members shall consist of Ordinary Members, Associate Members and Honorary Members, with Associates and Students," shall have added to it a footnote, as follows:—"Where the term "members" occurs in these Rules without qualification, it is held to include Ordinary Members, Associate Members, Honorary Members, Associates, Students, and Non-federated Members."

Rule 7.— . . . . whereupon he shall be entitled to all the privileges of membership, including a copy of the publications of the Institution for the year beginning the 1st of August which follows the Annual General Meeting prior to the date of payment of his first annual subscription.

Rule 14.—There shall be six ordinary general meetings in each year, to be held in Hamilton or elsewhere, as determined by the Council.

Rule 16.—All members shall have notice of and be entitled to attend all general and special meetings.

Rule 21.—The annual subscription of each of the various classes of members, as classified in Rule 2, shall be as follows:—

(a) Ordinary Members.—(1) Holders of a first-class certificate, either acting as resident responsible colliery managers, or in positions subordinate to acting colliery managers; (2) teachers of mining; (3) those in the employment of mining, metallurgical or mechanical engineers, or employed in a similar capacity at collieries—£1 5s.; (4) all others of this class, £2 2s.

. . . .

In the case of a member holding two offices, to each of which a different subscription would apply, he shall be held as occupying the position which involves the higher subscription.

The subscription for the first year of membership shall be determined by the position of the member at the date of election, and for subsequent years by his position at the date of the Annual Meeting in April.

Rule 27.—At least twenty copies of each paper and the accompanying discussion shall be presented to the writer free of cost.

Rule 30.—The copyright of all papers communicated to and accepted for printing by the Council shall become vested in The Institution of Mining Engineers.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
JANUARY 10TH, 1905.

MR. JOHN GERRARD, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. ALFRED DAWES, Mine Manager, Llithfaen, Pwllheli, North Wales.
Mr. WILLIAM HORROBIN, Manager, Bedford Collieries, Leigh, Lancashire.
Mr. CHADWICK LORD, Manager, Jubilee Colliery, Crompton, near Oldham.
Mr. JOSEPH WATERWORTH, Manager, Westleigh Collieries, Leigh, Lancashire.

DEATHS OF SIR LOWTHIAN BELL, BART., AND MR. H. H. BOLTON.

The President (Mr. John Gerrard) called attention to the death of Sir Lowthian Bell, Bart., President of The Institution of Mining Engineers; and of Mr. H. H. Bolton, of Rossendale and Accrington, a very old member of the Manchester Geological and Mining Society, and a vote of sympathy and condolence with the relatives of the deceased gentlemen was passed in each case.

Mr. G. J. WILLIAMS (H.M. Inspector of Mines) read a paper on "A Safety-brake for Hand-cranes" as follows:—

A SAFETY-BRAKE FOR HAND-CRANES.

By G. J. WILLIAMS.

In the North Wales quarries, especially in the slate-quarries, and also in the slate-mines, the so-called hand-crane almost universally employed is a four-legged derrick, which is used either for dragging heavy blocks of rock or for lifting them to a height and then lowering them on to a trolley or tram-waggon. Accidents with these cranes have been numerous and serious, often fatal, mainly through the handle flying back and striking a man on the head or face.

Fig. 1.—Lifting a Load with a Hand-crane: Ratchet and Pawl in Operation.

One of the Special Rules established under the Quarries Act requires that "every crane shall be provided with an efficient catch or an efficient brake." The cranes are generally fitted with a ratchet-and-pawl arrangement, which forms an efficient catch while a block is being raised, but as this must be thrown out of gear when lowering blocks, the remedy is but a partial one, and, in the writer's opinion, no mere catch can be efficient.

Within the last 10 years several safety-brakes have been invented for these cranes, but none of them have been adopted to any large extent: partly, no doubt, because the workmen would not take kindly to them, as they involved additional labour.

The latest and the most suitable brake that the writer has yet seen is illustrated in Figs. 1 and 2. It is simple in construction; the inventors, whose sole object was the saving of life and limb, have not patented it, and it enables the user to do his work with greater ease. This brake is described in Mr. Henry Hall's Annual Reports for 1901 * and 1903.† It was invented by Mr. John Jones, engineer at the Dinorwic quarry, and subsequently improved upon by Mr. John Jack, engineer at the Dinorwic quarry.

FIG. 2.—LOWERING A LOAD BY MEANS OF THE SAFETY-BRAKE: PAWL THROWN OUT OF GEAR.

The brake has been designed to be worked on single-purchase for a load not exceeding 3 tons, and it can be fitted to any existing crane. In its present form, it consists of a ratchet-wheel and a small brake-wheel keyed to the shaft of the pinion-wheel; and, upon a crank-shaft placed above the pinion-shaft, are keyed a single-arm crank and a bell-crank. The pawl for holding the ratchet-wheel is attached to the single-arm crank by a pin-joint.

* Page 81. † Page 41.

and the brake, for acting on the brake-wheel, is an iron or steel band lined with leather. The ends of this band, as well as the lever for actuating it, are attached by pin-joints to the bell-crank.

While the load is being lifted, it is checked and kept suspended by the ratchet-and-pawl, so that the handle cannot fly backwards. For lowering blocks of stone, the handles are removed, and the brake is then applied by means of the lever. The application of the brake automatically releases the pawl, which can be easily lifted up by the man applying the brake; a counterpoise, pinned to the pawl, keeps it in position, so as to be clear of the ratchet-wheel; and the load can be lowered at will, controlled by the brake.

It may be added that this type of brake is now used at the two largest slate-quarries in the world, employing about 5,000 men, and no mishap whatever has happened since its introduction.

There would be no difficulty in applying this brake to any pattern of crane.

Mr. G. J. WILLIAMS demonstrated the mode of working the brake, on a model.

Mr. W. OLLERENSHAW moved a vote of thanks to Mr. Williams for his communication, and said that the fact that the brake was so largely adopted, was a proof that its use had passed the experimental stage. He was pleased to learn that not a single accident had occurred whilst using the brake at any of the quarries where it had been adopted.

Mr. GEORGE B. HARRISON, in seconding the motion, said that many accidents had been occasioned, and sometimes lives were lost, for want of some means of protection such as this brake afforded. He was glad to know that it might be adopted freely, as it was not the subject of a patent.

The motion was cordially adopted.

Mr. A. J. TONGE asked, in the event of an additional shaft being used, so as to increase the power of the crane, whether the brake-arrangements were still retained, in the same form, on the first-motion shaft.

The PRESIDENT (Mr. John Gerrard) asked whether the mechanism was applicable to any form of crane.

Mr. G. J. WILLIAMS stated that the safety-brake might be affixed to any crane. There was no increased friction of the gearing.

Mr. JAMES ASHWORTH's paper on "Outbursts of Gas and Coal at the Morrissey Collieries, British Columbia" was read as follows:—

OUTBURSTS OF GAS AND COAL AT THE MORRISSEY COLLIERIES, BRITISH COLUMBIA.

By JAMES ASHWORTH.

Introduction.—Whilst the writer was in British Columbia a few months ago, Mr. R. G. Drinnan, the general superintendent of the collieries of the Crows Nest Pass Coal Company, Limited, favoured him with the particulars of unusually large outbursts of gas and small coal, in the No. 1 mine at Morrissey. The mine is situated about ½ mile east of the terminus of the Morrissey branch-line of railway, and about 4,000 feet above sea-level (about north latitude 49° 15′, and west longitude 114° 56′).

All the seams of coal worked at these collieries crop out at the surface; and at the No. 1 mine, the seam is a very soft, non-bituminous coal of irregular thickness, varying from 14 to 40 feet. The seam, dipping north-eastward at an angle of about 25 degrees, has a strong roof and floor. It probably corresponds with No. 61 seam, marked on No. 1 section of the Crows Nest Pass coal-field made by Mr. J. McEvoy.*

Three levels have been driven straight into the mountain-side, two of these serving as intake-airways, and the middle one as the return-airway to the fan. The lower level, the main haulage-road, entered about 20 feet above Morrissey creek and extended westwards for a distance of about 2,200 feet. It was cut in the top part of the seam, and had a rock-roof and a coal-floor. The ventilation of the mine was maintained by a fan, producing at the time of the outbursts about 60,000 cubic feet of air per minute, at a water-gauge of 0·75 inch. Three shifts of colliers were employed, and, although little or no gas was found in the mine, all the underground employees used Wolf safety-lamps (Fig. 1, Plate III.).

* "Summary Report on the Operations of the Geological Survey for the Year 1900," by Dr. G. M. Dawson, *Annual Report of the Geological Survey of Canada*, 1900, vol. xiii., section A, pages 84 and 95; "Summary Report on the Operations of the Geological Survey for the Year 1901," by Dr. G. M. Dawson, *Ibid.*, 1901, vol. xiv., section A, Nos. 759 and 767, maps.

Outbursts.—(1).—On August 6th, 1903, about 2·30 p.m. and whilst work was proceeding as usual, the coal at the face of the main level commenced to emit sounds as if the mine would close up. It was deemed advisable to withdraw the men; but, before they were all out of the mine, an outburst of gas and coal occurred, which very quickly filled the whole mine with gas. So great was the force exerted by the pent-up and escaping gas, that small coal and dust were blown out of the mine, across the creek, and the ventilation was reversed. It was noticed that the water-gauge in the fan engine-house remained unaltered. No entrance could be effected into the mine, until four days after the outburst, although the fan was kept running at its highest speed. About 1,456 tons of small coal were loaded out of the main level, and 174 tons out of the parallel level before the faces were reached. For a distance of 150 feet outbye from the face, the main level was completely filled with dust and small coal; and not a setting of timber remained standing in that length. About half of the coal-pillar, on the higher side of the level, was removed for a distance of 100 feet outbye from the face (Fig. 2, Plate III.): D being the portion of the pillar that was blown off, and E a cavity, 8 to 10 feet wide and 110 feet long, that was blown out at the same time.

(2).—After this outburst, the greatest precautions were taken to guard against a possible recurrence, but, despite these, another outburst took place on October 14th, 1903; and although it displaced only about 800 tons of coal, and the gas was smaller in volume, yet it was more disastrous, because 4 men were smothered by the fine dust and gas. It was evident from the position in which the bodies were found, 2 hours after the outburst, that they had had some premonition of danger, and had moved away from their working-places. The quick recovery of the bodies was due to the reversal of the fan, which, as is usual in this district, could be quickly converted from an exhausting to a blowing fan by mechanical arrangements placed within the engine-house of the fan. This provision for changing the direction of the ventilating current may seem a little strange, but it is sometimes resorted to in the winter months, to assist in clearing away accumulations of ice from the main intake-airways.

Several outbursts of gas of small volume had, previous to that

of August, 1903, occurred in the winning headings, but none had occurred in any other part of the mine.

The inspector of mines, in his annual report for 1903, wrote in reference to this mine, which he inspected every month:—"Notwithstanding the repeated outbursts of gas, I am bound to say that this mine could scarcely be put in better order. . . . They are working, in the first place, about 10 feet of the top. Ventilation is very good here; there are three connections with the outside, and they are making another near the face, where most of the men work, so that in case of an accident or outburst of gas the men in the upper workings will be almost outside. . . . . After one of these blowers has come away, it is quite a time before gas can be found in the mine."

(3).—An important precaution, which the management adopted, was to reduce the number of shifts worked to one in every 24 hours, so as to allow for gas-drainage, and for the following 13 months this appeared to have operated successfully; but, immediately after these notes were drafted, even this provision was found to be ineffective, and on November 18th, 1904, about 11·50 a.m., another huge outburst occurred, causing the deaths of 4 Englishmen, 10 foreigners and 2 mules.

The overman of the mine had just returned to the surface, after inspecting every working-place in the mine, and had found everything in its usual condition and not a trace of gas showing anywhere.

Only 1 man escaped from the mine: he was working at A, about 400 feet inbye on the main level (Fig. 1, Plate III.), when suddenly his lamp flared up and was extinguished, but this did not seem to have alarmed him, as he heard no unusual noise; he, however, felt as if something was catching his breath, and walked out of the mine to get his lamp relighted. Not until he saw a cloud of dust issue from the tunnel-mouth did he seem to have realized that anything was wrong. The dust found in the mine was as fine as flour, and that blown out of the mine with the gas was so fine that the men who saw it reported it as smoke.

For 35 minutes after the outburst occurred, it was impossible to approach any of the three entrances to the mine, although the fan was speeded to its utmost capacity; but after this interval

the fan commenced to gain the ascendency, and the rescue-party were able to move slowly along the main tunnel. The first body recovered, that of a brattice-man, was found about 500 feet from the entrance. This man was on his way into the mine, and had put down his lamp upright on the floor, a little farther inbye. It is supposed, therefore, that after his lamp was extinguished by the gas, he had put it down and attempted to escape. No. 2 was a miner, who was on his way out of the mine before the outburst occurred, he had, in fact, just finished a cut-through at the level-face near Brindach's place. Nos. 3 and 4 were drivers with a mule, and they did not appear to have made any effort to escape, as the body of the mule was between them and heading into the mine. No. 5 was another driver, who appeared to have suspected that something was wrong, and had left his mule near where No. 12 body was found. Nos. 6, 7, 8, 9, 10, 11 and 12 appeared to have left their working-places all together, and made an ineffectual attempt to escape. Inbye from No. 12 body, the level was practically filled up with dust, there being only an open space of 6 to 8 inches near the roof. All these men were carrying their lamps, but from the position of some of them it was assumed that they were walking in the dark, and had all come from working-places near the face of the upper level. No. 14 was the only man who was fully dressed, and had his lunch-bucket with him. No. 13 was the body of Greenman, who was working in the main level, and it was his duty, if anything went wrong, to see that all men were out, and then to close the safety-doors, B and C, situated near No. 7 body. These safety-doors were hung on strong frames, and were held open by strings, so that, in case of danger, the last man could close them behind him, and thus prevent gas and dust from overtaking him before he reached the outside of the mine.

It is quite clear that the first warnings of an outburst were not so definite in character as on previous occasions, and that they were not sufficient, at first, to alarm the men seriously, several of whom had been present when previous outbursts had occurred, and who were always on the outlook for signs of unusual pressure on the coal. This outburst also differed from previous ones in the total absence of violence along the roads. A safety-lamp would fill with flame, 24 hours after the outburst, when held on the top of the fan-chimney, and a week

afterwards there was a distinct cap on the lamp-flame in the return-airway.

The volume of air passing along the main level, as measured a few days before the outburst, was 57,000 cubic feet per minute, and the self-recording water-gauge, on the fan, showed absolutely no change during, before or after the outburst.

The mine had been shut-down for several months, and only a few places in the level-faces were being worked; and, for a month prior to the outburst, not a single report of gas had been made by the fireman.

The management estimate that this outburst displaced 3,500 tons of coal, 800 tons being removed to recover No. 14 body, which was found with fully 3 feet of dust under it, and it is supposed, therefore, that the man was wading through this depth of dust when he fell. One man, who was overtaken, was found in the attitude of running, upright on his feet, head leaning forward and hat on, and this fact, of itself, shows that there was no violence.

It is pretty clear from the foregoing particulars, that the men working at and near the face of the top level, received some warning before any check to the air-current could demonstrate to those on the road that an outburst was in progress, because they had run from 600 to 700 feet; whereas No. 5 had only run 500 feet, and No. 13, the same distance. Neither No. 1 nor the man who escaped appeared to have taken warning from the check to the air-current, as, had No. 1 done so, he ought to have escaped alive.

The check to the ventilation must, however, have been very severe, and its extent may be realized by noting that both of the intake air-currents were pushed towards the entrances of the mine, without the self-registering water-gauge in the engine-house of the fan showing any signs of increased pressure; and, therefore, it is fair to assume that the volume of gas given off must have exceeded 57,000 cubic feet per minute. Again, it may be noted that the volume of gas given off did not exhibit any signs of great violence, such as might have been expected if it had been suddenly released from a huge cavity. Nevertheless, it was enormous in volume, and continued at high pressure for 35 minutes, and at a diminishing pressure for a considerable time afterwards. It may, therefore, be reasonably supposed that

from 2,000,000 to 3,000,000 cubic feet of gas, at atmospheric pressure, were set free by the outburst in 35 minutes. Mr. James McEvoy, who does not accept the cavity-theory, estimated the volume of gas at 5,000,000 cubic feet.

Remarks.—It does not seem reasonable to the writer to imagine that this tremendous volume of gas could be pent-up in a cavity in the coal-seam, and, taking into account the great quantities of dust, which have been a feature of all the outbursts in this mine, he has considered several probable solutions of the problem. In doing so, he has noticed that petroleum and natural gas are found in these Cretaceous measures; and also that on the south-eastern side of this coal-field seepages of petroleum have been found, and petroleum has already been and is still being sought in the Flathead district of south-eastern Kootenay.

The presence of petroleum in this district opens up the interesting geological problem of its source. Geologists state that there are no rocks in the district likely to contain stores of petroleum, but prospectors allege that there is visible evidence of its presence in several places. The late directors of the Geological Survey of Canada, Dr. G. M. Dawson and Dr. A. R. C. Selwyn, personally examined the district and identified the rocks as belonging to the Cambrian age, in which oil has never been found, as they are too close-grained and compact to be capable of absorbing oil. Dr. Dawson calls it "a somewhat anomalous occurrence of petroleum;" and if, as he suggests, these older rocks have been, by a gigantic overthrust, slipped eastwards over the Cretaceous formation, then the overthrust fault must extend from 10 to 12 miles eastwards. Mr. W. F. Robertson, the Provincial Mineralogist for British Columbia, states that seepages of oil occur in three or more places; that there might be a body of oil underground, but that this is problematical; and that, although some oil was found in a bore-hole at a depth of 1,120 feet there was no flow, and he is not sanguine that even at a depth of 3,000 feet a profitable flow of oil will be obtained.

The writer has referred to the oil controversy, because he thinks that the outbursts of gas referred to as having occurred at Morrissey may, and probably have, some connection with petroleum. The samples of oil obtained by Mr. W. F. Robert-

son, and reported on by the Provincial Assayer, proved that the oils were of exceptionally low specific gravity: one sample consisted almost entirely of the lighter constituents of petroleum. It appears possible, and also probable, to the writer, that these frequent outbursts of gas may be attributable to the volatilization of light oil or spirit, which has been absorbed in patches of the soft coal, and, on being released by the removal or thinning of the surrounding coal, becomes volatilized with accompanying violence. As layer after layer of saturated coal is blown off, the dust is carried away by the gas, and the outburst continues until the oil-saturated mass is blown off and the oil or spirit volatilized. Under these conditions, the outburst would exert its greatest effect at the outset, and then gradually die away, as in the instances at Morrissey. If gas only were confined in a pocket, the writer does not see how so large a body of coal could be displaced; whereas, if a volume of oil were disseminated throughout a very soft portion of a coal-seam, which would, therefore, have the same absorbent qualities as a sponge, when the first burst occurred, the spongy coal would be carried away by the volatilization of the oil, and, as this proceeded, dust and gas would be continuously blown off, until the oil-saturated mass was exhausted. This supposition would allow of a very large volume of gas at high pressure being given off through a long period of time, and thus account for, what is at present, the mystery of the Morrissey outbursts. So problematical does the possibility of working the mine with any reasonable sense of security appear to the owners, that the writer understands that they have closed the mine.

In conclusion, the writer hopes that the subject may provoke discussion and suggestions from members, who may think that the mode of working, and the precautions taken to guard against such outbursts, can be so effectively improved, that the further working of the mine may be rendered reasonably safe.

The PRESIDENT (Mr. John Gerrard) said that in 1893* Mr. Joseph Dickinson read a paper on somewhat similar outbursts; and in 1899† he (Mr. Gerrard) read a paper describing the outbursts which caused such sad loss of life at the Broadoak

* *Trans. M.G.S.*, 1893, vol. xxii., page 239.

† *Trans. Inst. M.E.*, 1899, vol. xviii., page 251.

colliery, Ashton-under-Lyne. Having felt the responsibility of that anxious time, he could deeply sympathize with those having the charge of the Morrissey mine and he hoped that they might be enabled to prevent further loss of life.

Mr. ARTHUR MILLER said that, for 10 years, he was manager of the Broadoak colliery, which was specially liable to this class of outburst, and he appreciated the anxieties of the managers of the Morrissey colliery. The outbursts at the Broadoak colliery were not on so large a scale as those mentioned, but they were the cause of several fatal accidents. He recommended the managers of the Morrissey colliery to adopt the precautions which were found to be effectual at Broadoak colliery. The plan was to bore holes into the soft coal, from which the outburst came, and thus afford the gas a safe outlet. The coal was particularly soft in places, and contained large volumes of gas. When the hard coal had been worked away, and the soft coal was reached, a sudden outburst took place. This was obviated by boring, in advance, into the soft coal, and gradually liberating the gas. He thought that the best remedy would be to work the seam on the longwall system, if possible, with a wide face. The warnings used to be given by sharp knocking sounds, like the firing of a company of sharpshooters. When a fault was crossed, a bore-hole was made as soon as there was room, and more holes were drilled as the work proceeded. In this way, serious outbursts of gas were prevented. When he (Mr. Miller) took charge of the Broadoak colliery, Mr. Gerrard advised that bore-holes should be made; and the suggestion was adopted and continued until the mine was abandoned about a year ago.

Mr. HENRY BRAMALL said that he had been troubled with outbursts in the Rams mine, at Pendleton colliery, at depths varying from 2,500 to 3,500 feet; and he had not been able to account for them on any theory that had yet been broached. In his case, the characteristics were similar to those at Broadoak colliery, with the exception that gas was not given off. He was, therefore, at a loss to understand the cause, unless it were due to the great pressure bearing upon the coal. He suggested that the coal in certain places was different in its texture from the rest, and when the workmen had driven a place through one of those portions, which they call "hard knots," they had

suddenly released the support, and the pressure on the face had brought on an outburst of coal crushed into dust as fine as soot. On one occasion, so large a body of dust came out that it saturated the air in the return-airway and was carried to the shaft, a distance of 7,200 feet: the incline, for 6,000 feet, rising about 1 in 3. The pressure, causing the outburst, must have been very great, and the quantity of dust must have been very great also. Fortunately, they had never lost a life, nor had a man injured. He did not think that gas had played any part in the outbursts at Pendleton colliery, so that he was thrown back on the only other reason to account for them, and that was the extreme pressure due to the depth of the mine.

Mr. Charles Pilkington asked what kind of a roof there was on the coal. Possibly both the roof and the floor were very smooth, and, if so, that might, to some extent, account for the large quantity of stuff thrown forward. It used to be the fashion to pierce very gassy mines with narrow places, but that could not be done in all cases, and no doubt the only practicable plan was to make bore-holes in advance, as suggested by Mr. Miller. The bore-holes might be kept, say, 60 feet in advance of the face, and, say, 150 feet apart.

Mr. Arthur Miller said that the distance of the bore-holes was a question for the engineers to decide for themselves. It was best to err on the side of having too many bore-holes, and to drive them far enough in advance. In his case, three bore-holes were made in a place, 45 feet wide, and they were always kept at a minimum length of 5 feet in advance; and more bore-holes were driven in the leading roads.

Mr. Charles Pilkington suggested that the coal might be blown out, if the holes were only 5 feet long.

Mr. Arthur Miller said that it was possible to tap a place that relieved the pressure in a very large area. In the case of the last serious outburst at Broadoak colliery, when 3 men were killed, the area, although it was a large one, was not all open in front. The men were driving a level and the soft coal blew out of a narrow aperture. One could not say, therefore, how many, or how far the bore-holes should be in advance: that could only be determined after careful consideration of the circumstances. The greatest width of the cavity was 30 feet, and

the soft coal had been blown through an opening, about 3 feet wide. In ordinary cases, the cubic measurements of the cavity corresponded with the amount of material blown out.

Mr. George B. Harrison said that he had examined the cavities in the Broadoak colliery, and he was very much struck with their shape and size. There had evidently been great force, and the dust seemed to have come out of the softer portions of the coal-seam. In company with Mr. Miller, he had heard the indication which had been mentioned, but at that time there was no sign of gas. The men persevered with a bore-hole until it had penetrated the disturbed area, and then gas came off freely, so much so that they had to retreat. In the course of a few minutes, they were able to return, and, on again examining the bore-hole, he was surprised to find that it had been enlarged by the escaping gas sufficiently to enable him to insert an upright safety-lamp. The mine was deep, but the pent-up gas seemed to play an important part in producing the outbursts at Broadoak colliery.

Mr. A. Miller asked whether there was any intimation of weight on the roof at the time of the outbursts at Pendleton colliery.

Mr. Henry Bramall replied that there were indications of weight. The discussion had shown, to some extent, the difference between the outbursts at Broadoak and Pendleton collieries. In the latter case, nothing of the nature of a cavity was created and no gas was found, hence the outburst was solely due to the pressure on the face. The coal-face had been crushed into very fine dust, and generally behind that there had been a very "hard knot"—very hard and tough to get. Assuming the occurrence of a pocket of very soft, porous coal, saturated with gas under great pressure in a surrounding mass of hard coal, it was only a question of time until the surrounding wall of hard coal was sufficiently thinned and weakened for the gas to burst out and bring with it all the soft coal in a disintegrated form. The outbursts at Pendleton colliery were due to pressure; and those at Broadoak colliery were probably due to pent-up gas under enormous pressure, and probably contained in a pocket of soft coal saturated with gas. Then, although the hole made into such a pocket may be only 3 feet wide, it may bring out all the soft coal

and leave a large cavity behind. At Broadoak colliery, the gas was liberated by drilling; but at Pendleton colliery, drilling would be of no use. The mine is worked on the longwall system.

Mr. A. MILLER remarked that no outburst had occurred at Broadoak colliery where the roof was badly broken.

The PRESIDENT (Mr. John Gerrard) said it was proved, in the case of Broadoak colliery, that changes occurred in the strata and that frequently, before an outburst occurred, the mining portion of the seam was more clayey and less coaly; the stratum was hard. The small bore-holes frequently became choked, and they were more beneficial when the diameter was increased to about 3 inches.

Mr. J. ASHWORTH, replying to the discussion, wrote that the outbursts at Broadoak, Pendleton and Morrissey collieries had their separate and distinct characteristics, and were, therefore, of their kind, typical examples of these undesirable occurrences. The Morrissey mine differed from the others in that it had no hard coal; in fact, he did not think that it made any round coal at all. Since the last outburst, the mine had been closed, as there was clearly no known mode of working the mine, which would offer adequate security for the miners' lives. Mr. Miller and Mr. Pilkington had overlooked the fact that the No. 1 mine at Morrissey collieries was very thick, that nothing but narrow work was being driven in the mine, and that the levels were being driven in the top part of the seam close to the roof. Had the mine been still at work, he would have suggested that one level should be driven at the top of the seam with a rock-roof, and the other level close to the floor, so that the cut-throughs would intersect the seam from top to bottom. The character of the last outburst at Morrissey collieries did not give him (Mr. Ashworth) the impression of pent-up gas, but rather of a liquid volatilizing and throwing off layer after layer of oil-saturated fine coal. The levels had not been cleared up to the faces, and, therefore, no information could be given of the character of a possible cavity; but the cavity found after the outburst of August, 1903, was shown in Fig. 2 (Plate III.).

A hearty vote of thanks was accorded to Mr. Ashworth for his interesting paper.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING.

Held at the University, Birmingham, February 6th, 1905.

Prof. R. A. S. REDMAYNE, President, in the Chair.

The minutes of the last General Meeting were read and confirmed.

The following gentleman was elected:—

Student—

Mr. Abdul Hafiz, The University, Birmingham.

The Secretary (Mr. Alexander Smith) reported that the Council had appointed the following Committee, with power to add to their number, to investigate and report on the methods of working the Thick coal-seam of South Staffordshire under prevailing conditions, in accordance with a resolution passed at the last General Meeting:—The President (Prof. Redmayne), and Messrs. W. N. Atkinson, W. H. Chapman, W. Charlton, W. F. Clark, A. W. Grazebrook, L. Holland, J. Liddell and F. G. Meachem.

Mr. W. Lynch's paper on "Pneumatic Coal-boring Machines and Tools" was read as follows:—

PNEUMATIC COAL-BORING MACHINES AND TOOLS.

By W. LYNCH.

The writer has been told by mining engineers in the South Staffordshire district that a rotary power-drill was wanted, as the material in which the holes were drilled when driving headings, etc., was too soft to admit of the use of the percussion-type of drill, and the tool became clogged. The writer, therefore, some three years ago, experimented in one of the mines with an ordinary pneumatic drill as used in boiler-works, but he was not successful, because the feeding had to be done by hand.

Pneumatic tools may be divided into two classes, namely, rotary and percussion-rotary machines. The latter, which give a percussion-blow, are used for chipping, caulking, rivetting, etc.

Little Giant and Whitelaw Machines, fitted with Rock- and Ore-boring Attachment.—The Little Giant and Whitelaw piston air-drills are of a rotary type. They are probably well known to some of the members in their capacity of metal- and wood-boring machines, but the application of the rock- and ore-boring attachment has converted them into valuable machines for the quarry-owner. They will drill holes up to 2 inches in diameter, in hard iron-ore and similar material, at the rate of 3 feet per minute: the maximum depth attained, without shifting the bit, being 6 feet. The total weight of the heaviest machine being about 50 pounds, all sizes can be readily set up and operated by one man.

The rock- and ore-bearing attachment consists of a split nut, of simple and efficient construction, and the halves are readily replaced when worn out. When drilling, the links connecting the halves of the nut are locked, and the nut can be opened by one movement of the links so that the screw-bar can be at once withdrawn and the drill-bit changed. The best results can be obtained with air at a pressure of 80 to 100 pounds per square

inch, but the machines can be operated with 50 pounds: the air-consumption at the lower pressure being about 20 cubic feet of free air per minute.

Little Giant and Whitelaw Ore-boring Machines, fitted with Re-feed.—These machines are similar in character to the split-nut type, but are fitted with several novel and important details, by which, in the event of the drill-point meeting an obstruction, the drill will be automatically withdrawn for about 2 inches and then re-fed forwards, the whole of the operations taking place automatically, with the motor running continuously in the forward direction. The resistance, at which the slip will take place, is readily adjusted to suit varying conditions and circumstances. In this type of machine, the piston air-drill drives a quick-pitch screw-bar by means of a train of differential gear, which can be varied to give any range of feed required from $\frac{1}{12}$ inch per revolution. This is an important feature, as the slow feed is obtained in conjunction with a screw of coarse pitch, so that, by operating the lever controlling the clutch-gear, the screw-bar and the drill-bit are withdrawn at a rate equal to the pitch of the screw. The weight of the complete machine is about 60 pounds, and it will drill holes 2 inches in diameter at the rate of 3 to 4 feet per minute.

At some ironstone-mines, in the Cleveland district, the No. 8 Whitelaw machine drilled 40 holes, $1\frac{3}{4}$ inches in diameter, per shift, obtaining 66 tons of material, or an average of 1 ton 13 cwts. per hole: the air-consumption per minute, at a pressure of 50 per square inch, being 20 cubic feet. Two of these machines, when obtaining an average of 132 tons per shift with a total air-consumption of 40 cubic feet of free air per minute, kept 13 men fully employed. Comparing the work done by two Whitelaw machines with that accomplished by another type of pneumatic drill in use at these ironstone-mines, it was found that the two Whitelaw machines were capable of doing one-third more work. Further, while one man could lift the Whitelaw machine with ease, the other machine, on account of its great weight, required a horse, as well as a man and a boy, to move it from one part of the mine to another.

At Cowpen colliery, near Newcastle-upon-Tyne, with a No. 1 Little Giant drill, with the ore-boring attachment, having a feed-

screw of 5 threads to the inch, a hole was drilled in stone* to a depth of 2 feet 10 inches, with drills 1¾ inches in diameter, in 3 minutes 36 seconds, including the time occupied in changing the drills. A hole of similar length is drilled by hand in 20 to 30 minutes. In coal, a hole was bored by the machine to a depth of 3 feet in 2 minutes 50 seconds, including the time occupied in changing the drills; the same work, when done by hand, occupies about 10 minutes.

The Boyer Hammer with a Rotating Device.—This machine, designed for various classes of plug-and-feather work, is in use in the majority of the leading quarries throughout Great Britain. It is made in three sizes as follows:—1 $\frac{1}{16}$ inches by 4 inches, adapted for light drilling; 1$\frac{5}{16}$ inches by 1½ inches, for medium drilling; and 1$\frac{5}{16}$ inches by 3 inches, for heavy drilling. The best results are secured with an air-pressure of 80 pounds per square inch, and the hammers consume approximately 20 cubic feet of free air per minute at this pressure. The A type has an automatic rotating attachment; and the B type has a rotating attachment operated by hand, the tool used being an improved type of the wellknown No. 1 Boyer chipping-hammer. The light weight of these machines admits of their being easily held by hand, and they are therefore successfully utilized for either top or side-line work.

On account of the light, rapid blow employed, the drills used with these machines do not require sharpening so frequently as hand-drills; and 20 holes have been drilled with one of these machines, without re-sharpening the drill-bit. The nose of the machine is constructed for the use of standard ⅝ inch quarter octagonal steel-drills, thereby effecting a considerable saving in the time and expense of making drills.

On one occasion, 131 plug-holes, ⅝ inch in diameter by 3 inches in depth, were drilled in hard granite with one of these machines in 140 minutes, including the lining, changing of drills, etc. In a limestone-pit, this tool has drilled a hole 1¼ inches in diameter, 2 feet 2 inches deep, in 35 minutes.

Hand Rock-drill.—The hand rock-drill is adaptable for use either by hand or with a tripod, and its light weight, rapid

* The stone was blue metal or shale, with here and there a band of ironstone.

stroke, compactness and economy in air-consumption give it an immense advantage over other machines of this class. The device for freeing the hole from borings is a tube, which envelops the drill-bit, and by means of a blast of air running through it the hole is completely cleared of all obstructions. This arrangement is valuable, in cases where the class of rock that is being drilled does not necessitate the use of water. A water-connection, using hollow drill-steel, can be fitted when required. The machine, made in two sizes, has a stroke of $2\frac{1}{2}$ inches, and drills holes 1 inch and $1\frac{3}{4}$ inches in diameter, with a consumption of 30 and 45 cubic feet of free air per minute respectively, at an air-pressure of 80 to 90 pounds per square inch; and the drills weigh 25 and 45 pounds each respectively.

In limestone-quarries, these drills are capable of boring holes 1 inch in diameter and 2 feet deep in 16 minutes. The drill can be used in any direction; either horizontally, vertically or overhead. In a quarry in Wales, holes $1\frac{1}{16}$ inches in diameter and 7 inches deep were drilled into Pennant Rock in 4 minutes; and the hose used for conveying air for blowing the dust from the holes was worked successfully. With these drills, a hole, $\frac{5}{8}$ inch in diameter, can be drilled 5 inches in granite in 1 minute, and this speed can be kept up all day.

The drills have also been used in removing the concrete-foundations, preparatory to the erection of the Ritz Hotel, in Piccadilly, London, where, in excavating the site, the contractors unexpectedly came upon an old raft of concrete belonging to the buildings formerly on the ground. This was 3 feet thick, but it was readily removed with little difficulty, with the aid of these drills. Cartridges, with small charges of explosives, were used for blasting, to avoid any danger or disturbance, and the concrete was broken off in small lumps, easy to handle.

Conclusion.—There is, in the author's opinion, larger scope for the use of rock-drills in this country than has up to the present been realized; in many of the slate- and stone-quarries, the old system of hand-drilling is still in vogue, and even where machine-drills have been adopted, they are frequently found to be of old design and often discarded, no attempt being made to keep them in working order, or to replace them by modern machines.

Prof. R. A. S. Redmayne remarked that the use of rock-drills seemed not so much to resolve itself into the relative merits of rotary and percussion-tools as into hand *versus* mechanical drilling. Drills of the Ingersoll-Sergeant and Rand types were largely in use in the Western States of America, and in the British Colonies, especially in the Transvaal. The use of power-drills under certain conditions was a necessity, but he believed that, unless the rock was exceptionally hard and crystalline, it was cheaper, in ordinary conditions of colliery stone-work, to retain the old method of hand-drilling. There were, however, conditions, such as driving drifts through very hard rock, where hand-drills could hardly touch it, and in those cases it was undoubtedly necessary to use percussion-drills. When inspecting the ironstone-mines in the Cleveland district a little while ago, he was told that the percussion-drill could not compete with the rotary drill, and the ironstone being of course non-crystalline, this is what one would expect. The dust produced when drilling in crystalline stone was causing some anxiety at the present time, and he believed that it had been proved that tuberculosis was caused by the action of crystalline dust on the lungs of the miners working in the gold-mines of the Randt. An arrangement was wanted for water-spraying the hole while it was being bored. He did not think that power-drills for boring in coal would be adopted, because hand-drilling was efficient in coal and was cheaper than machine-drilling.

Mr. W. N. Atkinson (H.M. Inspector of Mines) thought that the chief obstacle to the adoption of power-drills for use in mines was the difficulty of supplying power to the tools at the place where they were required, and the ease with which coal was drilled with hand-tools. Power-drills would be useful for driving headings or drifts in stone. He thought that the method of blowing out the dust into the atmosphere of the mine was a disadvantage, and it would be a drawback to their use for drilling in stone. The gritty dust, thrown out, would undoubtedly be injurious to the miners, and a method of spraying water to lay the dust would be better than the air-spray. He could not remember many collieries where power-drills had been used for drilling in coal.

Mr. W. F. Clark asked whether the drills had been used in fire-clay, as they seemed particularly adapted for drilling in that material. The percussive machine, if fitted with a radial action similar to that of the Siskol machine, could be used to cut or slot the coal.

Mr. W. N. Atkinson pointed out that the view taken by the members was not an unfavourable one, but the points raised by the discussion showed the difficulties that had to be overcome in introducing pneumatic tools into a colliery. He had no doubt that their use would increase, in proportion as more mines were fitted with electric or compressed-air plants.

Mr. T. H. Bailey said that the greatest obstacle was the difficulty of supplying compressed air, and the initial cost of a plant required for that purpose. The tools were used in engineering-shops and boiler-yards, where they were only required to be used within a small area, and there was no difficulty in distributing the power; but it was a different matter in a colliery where some miles of pipes would be required, and the tool would only be used in one place for a short time. For driving cross-measures headings, the tools would prove of great value. He suggested that a portable drill might be worked by liquid air as a motive power, as it could be taken into the working-places in portable tanks.

Mr. W. Charlton asked whether provision had been made for the use of the drills for sinking purposes, as the drill would then require some other means of support than the tripod.

Mr. W. Lynch, replying to the discussion, stated that pneumatic drills were used for boring in coal in the collieries of the Transvaal. The rotary tools had given very good results when boring in fire-clay. He had recently installed a plant of six tools, supplied with compressed air through a pipe 3 inches in diameter and ½ mile long; an ordinary hose-pipe, ¾ inch in diameter, was sufficient for a single tool. A standard of the Elliott type had been designed: it consisted of a slotted bar allowing the drill to be used on any part of the face, from the floor to the roof; while for sinking, the bar was fixed horizontally.

Mr. Ewart C. Amos said that he had been acquainted with the use of rock-drills for many years, and in 1899, he read a paper

on "Machine Tools,"* in which he referred to pneumatic tools. At that time, pneumatic tools were rarely used in this country, but now there were many thousands in use. The tools described in Mr. Lynch's paper were as much in advance of the ordinary rock-drill, as they in their time were in advance of hand-drilling. In the Boyer tool, the piston-rod tapped the end of the bit, which gave it a considerable advantage over the Ingersoll-Sergeant machine: the bit in the latter case being connected with and fixed to the piston-rod, and, when jammed in the hole, it was difficult to get out on account of the machine being cumbersome and heavy to handle. The question of cost was comparatively unimportant, when compared with the importance of removing the material rapidly, and allowing the work of the mine to be carried on expeditiously. Especially was this the case where the mine was being developed, with a large capital lying comparatively idle.

Portable steam-driven air-compressing plants were in use on several of the great railways, and while it might not be convenient to use similar plants in a colliery, there would be no difficulty in designing a suitable portable plant for colliery work.

The PRESIDENT proposed a vote of thanks to Mr. W. Lynch for his paper.

Mr. W. CHARLTON seconded the resolution, which was unanimously approved.

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* *Transactions of the Society of Engineers*, 1899, page 51.

GOLD-MINING IN SOUTHERN RHODESIA.

By THOMAS WARTH.

Broadly speaking, Southern Rhodesia is a wide plateau 3,500 to 5,000 feet above sea-level, sloping northward to a height of about 2,000 feet, and with a gentler slope to the south, east and west. The watershed stretches from south-west to north-east, more or less dividing the country into halves; and the river-systems feed the Crocodile river on the south, and the Zambesi river on the north.

Climate.—The year is divided into the wet and the dry seasons, the former usually commencing at the beginning of November and lasting until the end of March or beginning of April. The wet season, however, is very variable: for instance, in 1896, the veldt was scorched, in fact the bush had put on an autumnal appearance by the end of March, and there was no more rain until the following November; whereas, in subsequent years, the writer has seen the rivers "down" in May, and the bush more or less green throughout the year. Many of the large rivers have deep beds of sand, and during the dry season, although there is no visible flow of water, water may always be found in most of them by excavating to a depth of a few feet in the river-bed; but, after a heavy fall of rain in the wet season, the water will sometimes rise, in a single night, to a height of 10 feet above the river-bed, and then, owing to the steep trend of the country, they pour "down" in an irresistible torrent.

By panning these sands, consisting of detritus of granite, metamorphic rocks and quartz, a "colour" of gold may usually be obtained if the sand be taken from the bottom of the river-bed, and, occasionally, rounded nuggets may be found.

The sand, varying in depth from a few inches to 20 or 30 feet, might serve as a medium for conserving water for mining

purposes, as its surface would preserve the water from evaporation. In a wide river, with a fair depth of sand, a dam might be built into the bed-rock, with a clay-core extended into either bank. The writer kept no data as to the percentage of water in the sand; but in 1897, on two consecutive days, about 4,000 gallons an hour or, say, 200,000 gallons, were pumped from the "latent water" in a section of a river-bed between two bars of rock: the section would be, approximately, 1,200 feet long by 300 feet wide, and the sand would probably average 5 feet in depth. On the third day, the water tailed off very rapidly.

During the dry season on the elevated plateau, the climate is almost ideal, for although at times the thermometer registers over 80° Fahr. in the shade, there is always a cool breeze. In the wet season, the heat usually increases until the rain falls, the thermometer sometimes registering 95° Fahr. in the shade. The heat varies greatly with a few feet of elevation: one may be nearly stifled riding through a "vlei," but on reaching higher ground the air is found to be cool and bracing.

Mining Regulations.—The whole of Rhodesia, with the exception of the Tati district, which lies in the south-western corner of Matabeleland, is administered by the British South Africa Company, incorporated by Royal Charter in 1889.

The steadily increasing output of gold has been as follows:—

	Oz.	dwts.	gr.
From the inception to 1898 ...	6,532	16	16
1898	16,378	4	7
1899	56,742	3	5
1900	85,366	11	16
1901	172,035	15	8
1902	194,168	8	2
1903	231,873	0	0
1904	267,736	0	0

In March, 1902, there were 334 stamps working in Rhodesia, and at the beginning of 1903, there were 370 stamps working, 68 in course of erection and 240 on order.

In February, 1903, the Rhodesian railway-system, including that in actual course of construction, comprized 2,193 miles, as compared with 2,396 miles in Cape Colony. The standard gauge is 3½ feet.

The mining laws of Southern Rhodesia entitle the British

South Africa Company to 50 per cent. of the purchase-money or scrip on flotation of a mining property; but this is never exacted, as the company usually takes only one-third, and gives credit for money spent on development.

The Mining Department is controlled by the Commissioner of Public Works and Mines, then, in order of authority, are the Registrars of Claims, the District Mining Commissioners and the Claim-inspectors. A record of all claims pegged, inspected, abandoned, etc., is kept at Salisbury, the capital of the country.

The territory is divided into mining districts, and the Mining Commissioner examines and reports on all mineral discoveries, settles disputes, issues licenses, and keeps a register of claim-holdings. The Claim-inspectors visit all mines, and report on the work done, etc.

The prospector, or intended future claim-owner, must first furnish himself with a prospecting license, only issued to *bona-fide* residents in the country, at a cost of 1s. On discovering a reef in place, the prospector is entitled to peg out a rectangular block of ten claims or less: a full-sized block measuring 1,500 feet by 600 feet (horizontal measurement). This area is known as a "regular location," "irregular locations" only being allowed where they fill in the small intervening spaces between blocks. On discovering an "ancient working" or a reef in place, the prospector puts in a "discovery-peg," and he is then exclusively entitled to prospect for 30 days within a radius of 1,000 feet, always presuming that no one else has previously fixed a similar peg within 2,000 feet of his own. On this peg, he places a "discovery-notice" which must be witnessed, and also state (*a*) the number of his license, and the place of issue; (*b*) a description of the discovery; and (*c*) the date and the hour of posting up the notice, with the signature of the locator. At any time, within the limit of 30 days, he must determine the bearing of what is to be the centre-line of his block.

The next step is the registration-notice, which must also be posted up within the limit of 30 days. A copy of this notice, together with an affidavit that it is a true copy of the one displayed on the ground, a plan of the block, showing the compass-bearings, and the license under which the ground is pegged must be forwarded to the nearest mines-office of the registrar of claims. The prospector then receives a provisional title, until

the ground has been surveyed by a licensed surveyor.* After the ground has been surveyed and named, a full title to the mineral and certain allied rights is granted, and remains valid as long as the annual claim-fees are paid, or until the ground is abandoned.

The prospecting license carries certain grazing, timber, water and building rights; and by special and general powers of attorney, licenses, titles, etc., may be readily transferred. These and many cognate matters are dealt with under the Mines and Minerals Ordinances Act, 1895, and subsequent amendments.

Geology.—As Rhodesia is, comparatively speaking, a new and little-known country, it will be many years yet ere the geological formations can be located and their divisions definitely correlated. The high plateau, forming the watershed of the river-systems, and embracing the main area of the country, consists of granites and gneisses, traversed by bands of metamorphic rocks: hornblendic, chloritic and other schists, of varying width. A portion is overlain by sandstones. The country, in the neighbourhood of the schists, is always more fertile and better wooded than that near the basement-granite. One well-known mining engineer states that the schists are metamorphosed sedimentaries; whilst others, including Dr. F. H. Hatch, believe them to be of igneous origin. Considering the very extended area of their occurrence, it is possible that some may be sedimentary, and some igneous, but the writer has noticed that all the schists that have come under his personal observation have invariably been crossed or traversed by basic or intermediate igneous rocks, such as diorite, dolerite, etc. The schists usually lie at a very high angle, at times vertical, their width is very variable, and the writer favours the theory that they had the same origin as the associated rocks. The intrusive dykes, in many cases, appear to have been forced upward before the matrix of the auriferous lodes was formed, as they have oftener taken the place of the quartz rather than faulted it.

The lodes usually follow conformably the foliations of the country-rock, both horizontally and vertically. Many of the

* To practise in Rhodesia, a surveyor must have passed (1) an examination in the theory of land-surveying at the Cape University, and (2) a practical examination conducted by the Surveyor-General of the Cape Colony; and (3) he must also obtain a license bearing a £5 stamp.

lodes are lenticular, appearing at times to have pinched right out, and a few feet farther on, opening out maybe wider than before. This variation makes mining very difficult, and renders the future of many mines highly speculative. It is generally admitted that the majority of the lodes are true fissure-veins, although some, especially where the foot-wall or hanging-wall is granite, have been found to narrow in depth and finally to pinch out altogether.

Sometimes, the country-rock is extremely contorted. In one prospecting shaft, sunk vertically with the intention of cutting a reef dipping westward at a depth of 120 feet, the lode was passed through at a depth of 80 feet, and then went down vertically, forming the hanging-wall of the shaft. At 100 feet a drive was started southward, following the strike of the reef, which after a series of corrugations, headed almost due eastward for a few feet, and was then blocked out by country-rock. Trenching on the surface, however, revealed what was presumably a continuation of the same reef, about 600 feet away, striking in the normal direction. The enclosing country-rock was extremely altered in nature, and was at times basaltic in appearance, giving every indication of comparatively recent volcanic disturbance.

The vein-gangue differs greatly in composition and in appearance, from very dark blue, almost opaque, indigo, brown and grey to what is termed " white elephant-stuff," being nearly pure silica, and usually barren. The colours are due to the presence of sulphides such as iron and copper; to carbonates, such as azurite and malachite, which are widely distributed; to oxides, etc. The majority of the outcrops of reefs have the distinctive reddish-brown tinge due to the oxidation of iron-pyrites.

Last year an interesting deposit of native copper was found in a prospecting shaft, within 60 feet of the surface. It occurred in arborescent sheets, between the jointing of the quartz. Malachite was strongly associated with the outcrop of this reef, and the gangue (passed through before striking the copper) was extremely pyritic, in fact it seemed to have altogether lost the nature of stone. Further prospecting had been stopped by an influx of water.

At the Ayrshire mine, in Mashonaland, the gold occurs in diorite. The mine-area embraces a huge intrusive dyke in the

granite, with its longest diameter bearing east-and-west. The gold was found in the diorite immediately next to a felspathic vein, which appears to traverse the mass, but the gold is now found more or less disseminated throughout the entire dyke.

Just as much as the reefs differ in occurrence, nature and grade, so do they in width. They are, sometimes, found as narrow as a few inches. The writer does not here refer to leaders, which, probably following the line of least resistance, branch off, sometimes at right angles along the jointing or cleavage-planes of the enclosing country-rock, but to veins having a regular defined strike for a considerable distance; and on the other hand, there are reefs many feet in width. The Monarch quartz-reef in the Tati district at one place, south of the main shaft, is said to be 80 feet wide.

The richness of the ore often varies in inverse ratio to the width of the vein. A reef, showing a wide outcrop and a low assay-value at the surface, may at an increased depth become narrower, and the vein-stuff, although less in quantity, will be of higher grade. The reverse law is also often true, and it will be recognized that, from a speculative point of view, mining in Rhodesia is in direct contrast to banket-mining in the Transvaal, where the gold is so evenly distributed, that the value of the gold-contents of a mine-area may often be approximately determined before even a shaft has been sunk.

Many outcrops of reefs show visible gold, especially when, by the oxidation or dissolution of the mineral constitutents, the stone has become honeycombed; and, on washing, fine grains of gold are generally discernible in the cavities previously occupied by the mineral particles. On crushing, this class of ore is often found to be deceptive, the whole of its gold-contents being visible and the body of the stone containing no metal in combination. Rhodesia has furnished hundreds of incredibly rich specimens: a sample from the Beatrice mine contained nuggets of the precious metal as large as marbles, and some hand-specimens contained several ounces of gold.

Ancient Workings.—This class of reef-outcrop attracted the ancients, who, at some period of the world's history, worked the veins for gold. Much has been written and many theories have been propounded regarding the probable origin and history of

these gold-seekers of antiquity; evidence of their handiwork is strongly indicated all over the country by excavations, now as a rule partly filled, and at times wholly effaced by deposited detritus, which has run in during supervening ages. They were also skilled masons and architects, as is evidenced by innumerable ruins of fortified strongholds and walled-in spaces, dotted over the country. These forts, usually built in the vicinity of the gold-reefs, imply that the builders were sojourners in a strange land and compelled to protect themselves from the natives. The theory that Rhodesia was the land of Ophir, whence the merchants and servants of King Solomon and the Queen of Sheba (probably following down the East African coast and landing at Beira) obtained the gold mentioned in the Bible* is worthy of consideration. Many of the Mashona boys bear strong traces of Semitic descent. These ancients extracted many thousands of ounces of gold out of the stone; this was easy enough, by crushing and washing, when the rock was soft; and, when the rock was hard, they appear to have adopted the method of heating the stone by fire and pouring water thereon, causing it to crack and become capable of being treated with their crude mining implements. Along most of the river-beds and banks, concave indentations in the granite may be seen, where the ancients evidently washed the crushed ore. When one considers the time and labour necessary to extract an appreciable quantity of gold, even from a very rich ore, in this way, one is compelled to infer that the work was probably performed by slave-labour.

Generally speaking, the workings on the reef are shallow, 20 to 30 feet may be taken as an average depth, and the three following reasons may be adduced to account for this limit:—(1) Their ignorance of appliances for hoisting mineral and pumping water; (2) the ore may have become refractory in depth, and the limited metallurgical knowledge of the workers would not enable them to extract the gold from it; and (3) they may have been obliged to quit the country by a superior force. It has been alleged that they worked downward until they came to

* *The First Book of the Kings, commonly called the Third Book of the Kings*, chapter x.; *The Second Book of the Chronicles*, chapter viii.; and *Great Zimbabwe, Mashonaland*, by Mr. R. A. Hall, leaves little doubt that Rhodesia was actually the land of Havilar, "where there is gold," of the Scriptures.

barren rock, but this view is absurd. The writer has taken out stone, forming the bottom of a working, assaying over 50 ounces to the ton.

The deepest old working seen by the writer was 105 feet down on the reef, but he has been told that in Mashonaland, a depth of 150 feet had been attained. An old working, in the Selukwe district, about 100 miles north-west of Bulawayo, is 3,000 feet long and 20 to 30 feet wide. In some places, where the reef is inclined at a comparatively low angle, pillars have been left to support the hanging-wall, in much the same way as might be done to-day.

Coal-fields.—The crystalline rocks and schistose bands containing the auriferous veins of the high plateaux, forming the backbone of Southern Rhodesia, may be regarded as a coast, bounded on its northern, western and southern shores by sedimentary strata. On the south, these are shallow and of small area, appearing to fill in the hollows, and lying unconformably upon the metamorphic rocks; but on the west and north, they are of far greater extent. In 1897, near Palapye, about 240 miles south of Bulawayo, a small seam of coal was discovered in these sedimentary beds by some miners sinking a well for the Rhodesian Railway Company, and it was hoped that workable seams might be found by boring. A bore-hole, after passing through sandstones, grits and shales, struck the basement-granite at a depth of 800 feet, without further coal being discovered.

On the west, these sedimentaries form the great Kalahari desert, a practically unexplored territory, which is supposed to have once formed a large inland sea, and it is gradually being filled up by detrital matter from the adjoining elevated country. Within recent years, the great lakes of Ntwe-Ntwe, Karri-Karri, etc., have dwindled into mere salt-pans.

About 250 miles north-west of Bulawayo, between the Gwaai river on the east, and the Kalahari desert on the west, are the Wankie coal-fields; while, also to the east, between the Gwaai and Sanyati rivers, lie the carboniferous areas of Lubu, Sengwe and Sesami. Good seams of workable coal, in shales and sandstones with occasional ironstone-bands, have been found, and are being developed with all possible speed.

The Coal-measures appear to lie immediately and unconformably on metamorphic rocks, and extend northward beyond the Zambesi river, having a gentle dip southward and south-westward. These coal-fields lie in comparatively close proximity to the Victoria falls.

Sir Charles Metcalfe, one of the consulting engineers to the British South Africa Company, recently suggested the harnessing of the falls to supply power for the working of the collieries. He pointed out that the available working head was 400 feet at the Victoria falls; that, with the recent rapid strides that had been made in electrical engineering, it would be possible to conduct current to a radius of 400 miles at a reasonable working cost; and that the falls had been so ordered by nature, that expensive tunnelling and other dead work, which had been necessary at Niagara for the installation of turbines and generators, would not be required.

It is a matter of regret that there is no native timber above a few inches in diameter within 80 miles of Wankie; but when the railway, now under construction, reaches the coal-field, easy access will be provided to the forest-belts of the south.

Labour.—Throughout South Africa, the labour-problem, which to-day is not solved,* has influenced mining to a greater degree than, perhaps, all the other difficulties which the mining manager has to overcome. The Transvaal Labour Commission found that "there is no source of Central or South African labour-supply for the wants of the Transvaal," and this statement may be applied, in a modified degree, to Rhodesia, for, although there will, probably, be a certain number of natives available from the numerous kraals in the country, these provide, unfortunately, the most unsatisfactory of all black labour. The fighting nature of the Matabele rebels against steady application to work, whilst the Mahola, or slave-tribes, such as the Makalakas, who originally were subject to the predominant race, are stupid, prone to disease, and physically weak. The worst feature of all is that, after working for two or three months and accumulating a little European clothing or a few goats with their earnings,

* These notes were penned before the introduction of Chinese coolie labour was definitely approved.

they return to their kraals, sometimes *en masse* and without warning, to exhibit their newly acquired possessions to their admiring relatives. During certain seasons, as when planting or harvesting the mealie crop, nothing will induce the natives to come down and work at the mines.

Geographically and by virtue of its population, Bechuanaland, or Khama's country, should be one of the best sources of mine-labour for Rhodesia, but most mine-managers will agree with the writer, that the Bamangwato are practically worthless on a mine. Their physique is fairly good, but less than 20 per cent. can be induced to go underground; they are lazy and independent, and sit round fires in circles, droning somniferous hymn-tunes and smoking *dagga*, in preference to working.

The best raw natives for mining, after the Shangaan, who come from the eastern border, are the Barotsi and Zambesi boys: they are physically strong, intelligent and obedient, learn quickly how to put in a shot-hole, and are not afraid of water or working in a wet shaft. As they have often trekked long distances from their kraals to find work, the journey sometimes occupying a month or more, they will, if treated justly, settle down for 12 months or more, before they think of returning home.

Individuality has a great deal to do with the control that a white man has over natives; some mine and compound managers can always procure boys, even when labour is scarce, and others can never obtain them; natives are prone to strong likes and dislikes to the individual white, sometimes for no apparent reason. Justice and tact are the greatest factors in commanding respect, and getting the best work from the native.

In one district, in 1896, the average wage for a good drill-boy was £1 a month, with as much mealie-meal as he could eat; the tendency has been, however, for wages to increase, and, in 1903, £1 15s. to £2 per month might be taken as the average wage of good drill-boys. Surface-boys are paid from 5s. to 15s. per month less wage than drill-boys, but "boss" or special boys may be paid up to £2 10s. Some managers also give a ration of beef once a week, or a little tobacco, or both, when they have boys that they do not wish to lose.

Compounds are usually erected for their housing, in order that they may be more readily governed and looked after, but

many natives prefer to build huts of saplings, long veldt grass, and *daka* or mud. There is usually a great deal of dissension between different tribes in the compounds and it is in settling these disputes that the tactful manager proves his value.

Skilled white labour is highly paid, a good miner or mechanic being able to command 20s. or more a day, but the demand at present is limited. Miners, timbermen, engineer mechanics, carpenters, battery-men and cyanide-men are most in request, but the allround man has the best chance of securing employment. The man who can put in a set of timber, drive an engine, erect a wood-and-iron building, and knows how to deal with Kaffirs, need not remain idle long, but the new arrival from Great Britain, however good he may be in his own trade, can seldom do this.

Timber.—Almost without exception, shafts, whether vertical or inclined, are sunk rectangular in section, and are usually close timbered with native poles, until sound rock is reached, and then timber sets, a few feet apart, are sufficient to carry the rails or guides; in vertical shafts, distance sets of imported pine are sometimes brought up to the surface, and the shaft is lagged with the same material.

The principal Rhodesian woods used in mining are the mapaani, knobbesdorn and native mahogany; of these, knobbesdorn is, probably, the toughest and most lasting. When used for permanent timbering, the poles should be decorticated: this is an easy task, if done at the time when the tree is cut down. For stations and lining the bins at the different levels, Oregon-pine may be used; this is very expensive, but native timber is difficult to work, and is seldom found large enough to cut economically into planks. In some districts, good mine-poles, 6 to 9 inches in diameter and 8 feet long, do not cost more than 1s. each, but longer poles for shaft-timbering (say, over 14 feet long) are not always readily obtainable, and their cost varies considerably in different districts.

Cordwood, for firing (this should be specified not to be under 3 inches in diameter), may be obtained for 15s. to 20s. a cord, measuring 8 feet by 4 feet by 4 feet. A cord of mapaani is, roughly, equal to from 10 to 15 cwts. of coal for generating steam. Up to the present time, owing to the heavy railway-

rates on coal, which has to be carried about 1,000 miles from the Transvaal or Natal, it has been customary to make wood-charcoal for the blacksmiths' forge and assayers' furnaces. This is usually done by digging a pit, wherein the wood is placed, and when, by combustion, carbonization has taken place, sand is shovelled in to extinguish the combustion. An intelligent Kaffir can generally be found to attend to this operation, and is paid from 1s. 6d. to 2s. 6d. a bag.

All timber, native or imported, in contact with the ground, excepting timber in the mine, should be creosoted or well tarred, as a safeguard against the ravages of white ants, one of the most annoying pests of the country.

Water.—Water is an important factor in the recovery of gold, and as the treatment of tailings by potassium cyanide has brought many low-grade ores into the range of payable propositions, the value of a generous supply of water has increased. In many districts in Rhodesia, there is running water all the year round, in others the construction of large dams will be a necessity. The rainfall is sufficient to supply water for mills and cyaniding on every reef in the country, but it only occurs during one season of the year, and the water rushes at great speed down the river-channels in the impervious rocks to the eastern coast, the Zambesi and Crocodile rivers being the chief outlets. A dam of any extent takes some time to build, consequently, a mining engineer should arrange that the building of the dam may run concurrently with his development, so that when the mill and the cyanide plant are eventually erected, there will be no drawback to continuous running. Referring again to the utilization of a sandy river-bed, where in close proximity to a mine, for the purposes of a reservoir, it would also serve as a filter for the treated sands from the vats, thus economizing the water; and when the river came down in flood the sands would be washed away and present a clean surface every year.

A dam, with a capacity of 40,000,000 gallons, is being built for the Eagle Vulture mine in the Gwanda district.

The dry crushing-plant, erected at the Wanderer mine, in the Selukwe district, has proved a complete success. This plant can treat 12,000 tons a month of ore carrying 4½ dwts. of gold,

and will probably be the forerunner of many similar plants in a country where lack of water has been the chief drawback to profitable exploitation.

Up to the present time, the writer has not heard of any shaft making insuperable quantities of water; and where the inflow has been sufficient to stop sinking, it has occurred in prospecting shafts of too small a sectional area to admit of the use of pumping machinery.

Railway-rates, etc.—All mining supplies, machinery and most food-stuffs enter Rhodesia duty free, and if the railway companies continue the policy that they have followed up to the present, namely, "that as the tonnage increases the rates are lowered," this drag on the wheel of mining progress will become less with each successive year.

The following items are specimens of the rates prevailing on the Rhodesian railways:—Natives, 0·166d. a mile; hay, 0·25d. a ton-mile; farm produce, 0·5d. a ton-mile; and concentrates, 0·75d. a ton-mile. The Wankie coal, which is already being used on the section of the railway between Salisbury and Machudi, will be carried at a uniform rate of 1·5d. per ton-mile northward of Bulawayo, and a through rate of 0·5d. per ton-mile southward of that town. It will cost about 30s. a ton delivered in the mining districts.

Conclusion.—To the experienced gold-mining engineer, who has roamed over different parts of the world, Rhodesia will probably present much the same aspect as other countries, where mining is carried on at great distances from the centres of civilization. He will note that, in common with most areas over which gold is distributed, it has natural advantages and disadvantages for successful and profitable mining. Among the former may be counted the climate, cheap native labour, timber, and, in most cases, favourable conditions for natural gravitation in the various processes employed in the recovery of gold. The irregularity of the veins, high costs of plant and supplies, with the uncertainty of when, after they have been ordered, he may rely on their being delivered at the mine, and the idiosyncracies of the natives may be classed among the disadvantages.

The ores may differ from others that he may have seen: for

instance, up to the present time, no telluride-ores have been found like those of Kalgurli or Colorado, nor is the ore exceptionally refractory, although, as usual, it tends to become more so in depth. Most of the rock-bearing quartz is harder than the banket of the Transvaal, and it is probably of much the same class as the quartz-veins of North Queensland. The engineer will use his own judgment as to the class of plant that the ore requires, whether the ordinary mill and cyanide, dry crushing, breakers or rolls, concentrating and grinding, ordinary precipitation or electrical deposition, and the hundred and one details which the ingenuity of man has devised for the successful treatment of the never-ending variety of ores which Nature is continually producing for the world's advancement.

The preceding notes were written in December, 1903, before the recent discoveries of banket in the Lomagundi district, and alluvial gold near Zimbabwe. The author has, at present, no remarks to offer on these discoveries, except that he feels confident they will prove of immense value in the future of the country.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING.
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
MARCH 6TH, 1905.

MR. W. N. ATKINSON IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen, having been previously nominated, were elected:—

MEMBERS—

Mr. RICHARD BUTLER, Mutual Buildings, Johannesburg, Transvaal.
Mr. W. J. HEPPELL, Cwmaman Collieries, Aberdare.

Mr. A. HASSAM read the following paper on "The Taxation of Collieries."

THE TAXATION OF COLLIERIES.

BY A. HASSAM.

INTRODUCTION.

The burden of maintaining the public institutions of the country is borne by the people in the shape of imposts, divided broadly into the two divisions of Imperial and local taxation. Although it is absolutely necessary that funds should be collected for various public purposes, taxation is always more or less unpleasant and unpopular. This largely arises from the fact that it is impossible to secure any system, by which the incidence of the burden will fall equitably on all classes of payers, and therefore, under one impost or another, almost every individual considers that he has a grievance. Many attempts have been made by the Legislature to equalize matters, but there is still room for further improvement, although, from the very nature of things, real equality of burdens cannot be attained.

Deep dissatisfaction has been, and is being expressed, throughout the length and breadth of the kingdom at the heavy and extravagant expenditure of the various local spending authorities. Municipal indebtedness has increased by leaps and bounds, and many large corporations are only awaiting favourable opportunities to make still further floatations. The municipal debt is £370,607,493, or nearly half of the national debt. It has increased during the last 28 years by £277,787,393, equal to 300 per cent. As against this, the rateable value has been augmented by £63,516,900 only, shewing an increase of 54·9 per cent. But the annual burden has advanced, in the same period, from £19,198,579 to £50,328,412, being an increase of £31,129,833, equal to 162·1 per cent. Hence the nett result is, that at present the municipal debts of England and Wales are more than double the rateable value of the property on which they are based, and, during the period named, after allowing for

the enhanced value, the actual burden in the pound has increased from 3s. 3·8d. to 5s. 7·4d., an advance of 2s. 3·6d. or 70 per cent. These results are best shewn by Table I., which gives the figures for the years 1874-1875, and 1902-1903, and the comparison shews the startling growth of loans, rates, etc. This condition of affairs is of extreme gravity, particularly when the question is considered in conjunction with the sister-burden of Imperial taxation, which is also growing enormously. Local rates have gone up higher and higher, until in some places they are equal to half the rateable value, notwithstanding that the assessments have been expanded to the extreme limit, and frequently beyond, which means an actual taxation-burden higher than the mere poundage would apparently indicate.

TABLE I.—LOCAL RATES, LOANS, ETC.

	1874-1875.	1902-1903.	Difference.	Increase per cent.
1. Population	23,724,834	32,997.626	9,272,792	39·1
2.—Gross rental... ...	£136,408,462	£231,089,809	£94,681,347	69·2
3.—Assessable value ...	£115,646,631	£179,163,531	£63,516,900	54·9
4.—Deductions and allowances ...	£20,761,831	£51,926,278	£31,164,447	47·3
5.—Percentage of deductions	15·2	22·4	7·2	
6.—Rates paid	£19,198,579	£50,328,412	£31,129,833	162·1
7.—Amount in the £ ...	3s. 3·8d.	5s. 7·4d.	2s. 3·6d.	70·0
8.—Rates per head of population ...	£0 16s. 2d.	£1 10s. 6d.	£0 14s. 4d.	88·2
9.—Outstanding loans ...	£92,820,100	£370,607,493	£277,787,393	300·0
10.—Loans per head of population ...	£3 18s. 3d.	£11 4s. 8d.	£7 6s. 5d.	187·3
11.—Contributions from the Exchequer ...	£1,681,399	£12,782,803	£11,101,404	660·0
12.—Total rates and Imperial contributions	£20,879,978	£63,111,215	£42,231,237	202·0

It will be observed that the poundage has increased 70 per cent.; but this is far from being a measure of the extent to which industrial undertakings are affected. The fourth line of Table I. indicates that the deductions are 47·3 per cent. more generous than in 1874, and it might be inferred that the advantage was general, but this is not the fact. The increase is due entirely to the relief granted to agriculture by the Agricultural Rates Act, 1896, and it follows therefore that all other sections of the community are labouring under an increase of poundage much higher than the average increase of 70 per cent.

It will also be noticed that local rates have been relieved to a very great degree by grants and subventions from the Imperial Exchequer; or the apparent burden would be increased by over 25 per cent. While only £1,681,399 was received from this source in 1874-1875, the sum of £12,782,803 was contributed in 1902-1903. It must, however, be distinctly understood, that at the best, this is only a shifting of the burden; and the stern fact still remains, that the cost of local administration, from one cause or another, has advanced in 28 years from £20,879,978 to £63,111,215, or 202 per cent. increase, as against an increase in the population of 39·1 per cent. In other words, the cost is increasing six times faster than the population, and thoughtful men are being led to ask what the end is going to be.

The increase has become so general and so heavy that from all sides one hears grumbling and dissatisfaction, and the effect upon industrial undertakings in our large centres of population is to be deprecated. It places a very heavy burden upon manufacturers, which, in these days of keen competition, is difficult to bear; and if it does not really cause established businesses to close, it certainly prevents that natural expansion which might be otherwise expected. Public feeling upon the matter has become so acute, that a Royal Commission has been enquiring into the subject of local taxation, and several reports have been issued, with certain recommendations, one of which, relating to the valuation of collieries and mines, will be considered more fully further on.

The writer has been led to make these general remarks, which he hopes will not be considered out of place, by his feeling that this enormous and sudden growth of local debts and burdens is of such serious and grave moment to every subject in the kingdom, and particularly to those interested in the coal-industry, with its enormous capital-outlay, as to demand a close watch upon developments in this direction, in order that their concerns may not be inequitably taxed. Amongst the whole of the industries in the kingdom there is perhaps none upon which the burden of taxation falls with more injustice, and with less reason and system, than collieries. They derive comparatively little benefit from the expenditure of the sums which they provide, and frequently the amount which is demanded from them is arrived at by some wonderful system shrouded in mystery.

In dealing with the figures affecting this question, the writer will confine himself to England and Wales only, so far as local taxation is concerned; but the few remarks that he will make concerning income tax, which is all that will be touched upon under Imperial taxation, will apply generally.

Income Tax.

Collieries, in common with other mines, were assessable as to the income tax under the Income Tax Act, 1842, Schedule A., No. III., on the full gains for one year, or an average of the five preceding years; but if, from some unavoidable cause, any mine has been decreased and is decreasing in the annual value, so that a five years' average will not give a fair and just estimate of the annual value, such annual value can be computed on the actual amount of profits for the preceding year, subject to the usual abatement, on account of diminution of duty within the current year; and if any mine shall have wholly failed, the assessment can be wholly discharged.

By the Act of 1866 (29 and 30 Vic., cap. 36) this was modified, and it was enacted that "the several and respective concerns described in No. III. of Schedule A. . . . . shall be . . assessed . . . . according to the rules prescribed by Schedule D. . . . , so far as such rules are consistent with the said No. III.," and Schedule D. provides that the assessment shall be upon the balance of profits and gains "upon a fair and just average of three years."

This alteration appears to have left the question as to whether collieries should be assessed upon a three years' or a five years' average in some uncertainty. In the case of Knowles *v.* McAdam, it was held that the three years' period was applicable to colliery-concerns, but this was dissented from in the House of Lords in the case of the Coltness Iron Company *v.* Black, in which Lord Blackburn said, "If the effect of section 8 was to transfer cases in Schedule A. No. III. to Schedule D., it would change the respective times on an average for which the profits were to be assessed. Mines would be reduced from a five-year period. Quarries and things of that sort would be raised from a single year to three. I cannot think this was either intended or expressed. But, on the assumption that it had this effect, the Exchequer Division came in Knowles *v.* McAdam to a very startling decision."

Whichever period may be the right one, it is the general custom to work on a five years' average, and it is specifically stated in the 47th Report of the Inland Revenue Commissioners that the returns for mines are on the five years' period. It is, however, within the writer's knowledge that several instances have occurred where the three years' period has been accepted by the Surveyor of Taxes. On rapidly decreasing annual profits, a very great advantage may accrue to an individual taxpayer by taking three years instead of five years; for the profits of the first two years out of the five may be enormously in excess of those of the other years. It is difficult to understand why the revenue authorities should allow some collieries to pay on a three years' average and select their own time for doing so, and demand a payment based on a five years' average from others.

The matter operates in this way: for example, take a colliery having earned profits for five years, as follows: 1899, £15,000; 1900, £40,000; 1901, £20,000; 1902, £10,000; 1903, £1,000; the average profit being £17,200.

The same colliery, by being allowed to take the last three years' average, would work out at £10,333, a difference of £6,867, which at 1s. in the £ would effect a saving of £343 7s. on that particular year. It is certain that any colliery-proprietors who are allowed to do this are securing an advantage over their fellow taxpayers, which it is difficult to reconcile with either justice or reason. As a matter of principle, the same treatment ought to be extended to all, if to any. Of course, if there is some "specific cause" through which the profits and gains fall short, a colliery is entitled to have the computation made on the annual profits, that is, the gains for the current year, and it has been held in Ryhope Colliery Company *v.* Foyer that a diminution of profits from an extraordinary depression in the coal-trade is a "specific cause" in this sense. The actual amount of money contributed by any concern over a considerable number of years, is the same whether based on the three or the five years' average, so long as the same period is always taken; any injustice or irregularity can only arise when a change is made from one period to the other.

One effect of the five years' average period is that income tax is paid on profits and gains years after those profits and gains are earned and, in many cases, spent. This point is plainly illus-

trated by the last report of the Inland Revenue Commissioners, and Table II. shows the income-tax assessment for mines for the last ten years.

TABLE II.—INCOME-TAX ASSESSMENT FOR MINES FROM 1893 TO 1903.

	Rate per Pound. s.	d.	Valuation.
1893-1894	0	7	£12,321,709
1894-1895	0	8	12,675,658
1895-1896	0	8	12,278,462
1896-1897	0	8	10,509,292
1897-1898	0	8	9,077,828
1898-1899	0	8	8,901,108
1899-1900	0	8	£9,491,684
1900-1901	1	0	12,030,910
1901-1902	1	2	17,641,593
1902-1903	1	3	20,258,907
Average			£12,518,715

The amount paid to the revenue last year was the highest ever paid, although the actual profits in the coal-trade for that year were, no doubt, very low. But the five years upon which the last payment had been assessed took in more good years than any previous period, and hence the anomalous position of many collieries paying income tax on profits earned five years ago, although now actually working at a loss. Of course, it is quite clear that, when times become good, the same law operates to defer the payment of profits, when they are earned, by bringing in previous bad years.

If the poundage was always the same, there would be nothing unfair about the principle; but in any case it is very much open to question whether it would not be better and more convenient, so far as collieries are concerned, if the assessments were based on the profits of the preceding year, like ironworks, quarries, gasworks, etc. The tax would then be paid when the profits were practically in hand, and the effects would in many instances be less felt. It seems absurd in the extreme that colliery-people in a bad year like last year, should pay the National exchequer on account of ostensible profits, on an assessment of £8,227,997 more than in the prosperous year of 1900.

Owing, however, to the fluctuations of both poundage and profits, the five years' period can operate very unfairly, and by an unfortunate coincidence, has, as a matter of fact, very adversely affected colliery-proprietors during the last two or three years. For instance, if the assessments had been based on current profits, payments made in 1899-1900 would have been at 8d. in the £, and the next year at 1s. and so on. But as the profits from these good years are, by the average system, brought in when actual profits are very low, and the poundage has ad-

vanced to 1s. 3d., it follows that the income tax is being paid at the higher rates on profits earned when the assessment was only 8d. in the £. This point is illustrated by Table III. which shews that, in the assumed case, the five years' system has led to the payment of (£4,407 10s. less £3,904 3s. 4d. or) £503 6s. 8d. more than would have been due under the one-year system, or an increase of nearly 13 per cent. over ten years. Of course the effect might have been in the reverse direction, but unfortunately it was not.

It may be objected that the profits in the assumed case are too high during the good years. This may be so, but it does not affect the justice of the argument, as it is only a question of degree. Assuming the difference to be 10 instead of 13 per cent., it is still a serious item. The total contribution to the National exchequer by collieries during the last ten years has averaged about £600,000 per year. It therefore appears that colliery-owners have paid, during the last few years, about £500,000 more for income tax than they would have done under the single-year system.

TABLE III.—THE COMPARATIVE EFFECTS OF INCOME-TAX ASSESSMENT ON THE ONE YEAR'S AND THE FIVE YEARS' AVERAGE BASIS.

Year.	Assumed Profits Per Year.	Income Tax per £	Amount paid. On One Year's Average Basis.	Amount paid. On Five Years' Average Basis.
	£	s. d.	£ s. d.	£ s. d.
1894-1895	2,000	0 8	66 13 4	66 13 4
1895-1896	2,000	0 8	66 13 4	66 13 4
1896-1897	2,000	0 8	66 13 4	66 13 4
1897-1898	2,000	0 8	66 13 4	66 13 4
1898-1899	15,000	0 8	500 0 0	153 6 8
1899-1900	40,000	0 8	1,333 6 8	416 13 4
1900-1901	20,000	1 0	1,000 0 0	790 0 0
1901-1902	10,000	1 2	583 6 8	1,015 0 0
1902-1903	2,000	1 3	125 0 0	1,087 10 0
1903-1904	2,000	0 11	95 16 8	678 6 8
TOTALS ...	£97,000		£3,904 3 4	£4,407 10 0

LOCAL TAXATION.

Local taxation differs very greatly from the income tax question, and is of a very complicated nature. The statute of Elizabeth specifically made coal-mines rateable to the poor,

and the Rating Act, 1874, made all other mines rateable. They are also liable to the county, borough, highway and other rates. The basis upon which the assessment valuation is to be made, is stated as follows in the Parochial Assessments Act, 1836: "Upon an estimate of the nett annual value of the several hereditaments rated thereunto; that is to say, of the rent at which the same might reasonably be expected to let from year to year, free of all usual tenants' rates and taxes, and tithe commutation rent-charge, if any, and deducting therefrom the probable average annual cost of the repairs, insurance, and other expenses, if any, necessary to maintain them in a state to command such rent."

This basis is perfectly clear and easy to adopt in regard to many properties, but in respect of others, considerable difficulty arises. There is, perhaps, no class of property about the rateable value of which more controversy has arisen than coal-mines, and several very notable cases are on record. The difficulty of dealing with this matter has been felt ever since coal-mining began to assume large proportions, and the position is not ameliorated in any way by the present astounding increase in the rates in some localities.

Before referring to any suggestions which have been made concerning the question of the rateability of collieries, the writer proposes to endeavour to ascertain what is the present practice adopted in arriving at the amount of annual value at which a coal-mine should be assessed for rating.

As before hinted, a good deal of quite unnecessary mystery usually surrounds the method. Certain information is generally obtained from the colliery, and then a demand note is sent, but how the amount of annual value which the hypothetical tenant would pay is really obtained, the actual tenant is not always informed. In the case of any ordinary property, this information is readily obtainable; it is, in fact, absolutely necessary, if ratepayers are to check the amount of their assessment, and the writer cannot understand why any mystery should be made about the basis of the assessment of a colliery.

This secrecy of method of valuation, as between one union and another, perhaps more than the really inherent difficulties of valuing such variable properties as collieries, is responsible for the widely varying results in different unions. An examination of the bases of valuation throughout the 145 unions of England

TABLE IV.—SUMMARY OF THE RATING OF COLLIERIES IN ENGLAND AND WALES FOR THE YEAR 1890.

Rate or Basis of Assessment.	No. of Unions.	No. of Mines.	Valuation. Gross.	Valuation. Rateable.	Deductions. Average per cent.	Deductions. Remarks.
			£	£		
1.—Sliding scale on value of coal, one-twelfth to one-fourth	7	101	95,030	81,167	14·65	15 to 50 per cent.
2.—Receipts, less expenses	3	11	5,981	4,774	20·24	15 to 25 per cent.
3.—Output at 3d. to 8d. per ton, without deductions ...	5	60	73,854	73,854	Nil	—
4.—Output at 3½d. to 2s. 6d. per ton, with deductions	9	175	267,938	243,041	9·33	5 to 25 per cent.
5.—Output at an unknown basis	11	209	527,633	415,230	19·78	Nil to 40 per cent.
6.—Amount per ton on the output for the nett value, and 5 to 25 per cent. added to obtain the gross value	8	290	707,642	594,110	16·15	—
7.—Output at 3½d. to 1s. per ton, shafts at 1d. to 1½d. per ton, and machinery at 6 to 7½ per cent. of the capital value	14	301	629,963	556,743	11·64	Nil to 33 per cent.
8.—Output, and separate valuation of machinery, etc. (no basis stated)	11	153	401,881	351,580	12·47	Nil to 25 per cent.
9.—Sliding scale of 2½ per cent of the selling value of the coal, plus £5 per acre for land	1	12	4,777	4,777	Nil	—
10.—Royalties and rents, without deductions	5	43	11,241	11,241	Nil	—
11.—Royalties and rents, with deductions	25	131	96,668	81,438	15·00	4 to 25 per cent.
12.—Royalties and rents. plus valuation of machinery. etc.	8	64	81,556	73,714	9·57	No deduction on coal, but only on machinery, etc.
13.—Royalties and rents, plus valuation of machinery. etc.	9	212	133,272	114,770	12·60	—
14.—Acreage, up to £120 per acre	3	44	27,899	24,754	13·79	Nil to 25 per cent.
15.—No basis stated	6	34	65,653	57,140	12·94	Nil to 20 per cent.
16.—Professional valuers: basis not stated	20	245	463,609	399,627	15·89	Nil to 42 per cent.
TOTALS	145	2,085	£3,594,597	£3,087,960	14·13	

and Wales is at first sight bewildering. Almost every Assessment Committee appears to be a law unto itself, and in cases where a tonnage-basis is adopted, the rate per ton varies from 3d. to as high as 2s. 6d. and deductions range from *nil* to 50 per cent. Some valuations are based upon royalties alone, others take no notice whatever of royalties, while some again, in addition to royalties, add a further value for certain plant. Others again have a sliding scale based on the value of the fuel, and there are many other variations.

There are no ordinary annual Government returns giving full information upon these points, but on several occasions the information has been asked for in Parliament, and papers presented. Unfortunately there has been nothing later than 1890, but still, apart from the known expansion in quantity of coal wrought, and one or two assessment appeals, it is pretty certain that the present general condition of things is substantially the same as therein indicated, and the same lines of valuation are in force in the respective unions now as then.

The writer has endeavoured to analyse the returns, and has drawn up a rough classification (but it must always be understood that there are many minor differences, even in those unions which are included under one head) and Table IV. is a summary shewing the rating of the collieries in England and Wales for 1890, divided roughly into 16 classes. An examination of Table IV. shews, at a glance, the enormous differences which exist in the manner of arriving at the valuation of a coal-mine, and no doubt can be left in any mind that considerable inequalities and unfairness of incidence must arise. In fact, that they do exist is only too well known, and many instances can be cited.

The inequalities are also further exemplified in a striking manner by Table V., which shews the tonnage wrought in the different counties, and the estimated pit-values, for the year 1889, practically the same year as that of the rating returns. The gross and nett values for the counties are shewn, and worked out per ton of output. On the large output of Glamorgan, the valuation averages 8·44d. per ton, or four times the amount in Derbyshire, which is 2·09d. per ton.

The Commissioners on Local Taxation say: "The witnesses [for special properties] who came before us did not complain so much as to the amount of the valuation, as of the inequality in the valuation of one property compared with another in different

districts. Their complaints appeared to be chiefly directed against the expense and the want of uniformity and principle which prevails with regard to the valuation of these properties, and the uncertainty which exists in the minds of business-men as to the results."*

TABLE V.—TONNAGE WROUGHT, AND GROSS AND NETT RATEABLE VALUES FOR THE COUNTIES OF ENGLAND AND WALES.

Name of County.	Amount of Coal.		Gross Rateable Value.		Nett Rateable Value.	
	Tons.	Estimated Value.	£	Per Ton.	£	Per Ton.
		s. d.		d.		d.
Cheshire	620,101	7 0	18,161	7·03	15,907	6·16
Cumberland	1,739,491	5 9	40,749	5·62	34,931	4·24
Derby	10,093,222	7 9	87,373	2·09	74,498	1·77
Durham	30,307,177	5 2	678,742	5·37	603,381	4·78
Gloucester	1,359,814	8 10	23,349	4·12	21,144	3·81
Lancashire	21,707,867	6 6	522,827	5·78	432,931	4·76
Leicester...	1,336,574	7 1	25,323	4·54	22,213	3·99
Monmouth	6,751,308	7 5	161,329	5·73	154,279	5·63
Northumberland ...	8,794,005	5 4·7	172,010	4·68	147,786	4·03
Nottingham	6,582,582	7 0	196,349	7·16	165,011	5·74
Salop	710,490	7 0	16,025	5·42	14,622	5·00
Somerset...	876,254	8 1	15,587	4·27	13,177	3·61
Stafford	13,937,406	6 5	273,698	4·72	229,072	3·93
Warwick	1,700,490	7 0	19,015	2·68	15,529	2·19
Westmoreland	1,246	7 0	75	14·51	70	12·69
Worcester	893,880	6 5	24,470	6·57	20,714	5·53
Yorkshire	21,976,027	6 6	552,139	6·00	479,900	5·23
Brecknock } Caermarthen }	944,652	6 8½	23,650	6·00	19,726	4·87
Denbighshire	2,180,316	6 3	30,533	3·35	27,483	3·02
Flint	715,183	6 3	4,531	1·52	4,252	1·42
Glamorgan	20,297,004	8 2	714,063	8·44	587,851	6·95
Pembroke	71,271	9 6	1,840	6·19	1,381	4·64

In his evidence before the Commission, Mr. Ratcliffe Ellis, the Secretary of the Mining Association of Great Britain, said: "This absence of uniformity in the different counties and the different unions, the Mining Association considers to be most unsatisfactory, and that in order to secure equality of rating both as between collieries *inter se,* and as between mines and other classes of property, some provision should be made by Parliament prescribing some uniform mode of rating."†

One peculiarity of the present order of things is, that while the greatest elasticity exists as between different unions, the rule

* *Royal Commission on Local Taxation: Final Report of H.M. Commissioners appointed to inquire into the Subject of Local Taxation,* "England and Wales," 1901, pages 60-61.

† *Ibid., Appendix to Minutes of Evidence* (vol. i.), *taken before the Royal Commission on Local Taxation,* part ii., 1898, page 70.

adopted in any particular union is frequently applied with cast-iron rigidity to all collieries within that union, without reference to the particular conditions under which different collieries may be working; and it is easy to see how, under such a course of procedure, injustice can be readily inflicted. As an illustration, take two collieries in the same union, each with an output of about 250,000 tons per annum. The workings of one are in a flat area, comparatively free from faults and natural difficulties; the other finds its mines badly contorted, faulted, and heavily watered, the costs of working being thereby largely increased, and the expenses necessary to maintain the mine in a state of repair to command a rent, much heavier in the one case than in the other. Would the hypothetical tenant pay the same rent from year to year, for the difficult colliery as for the other? Certainly not! although as a matter of fact, the output from the one equals that from the other; and probably the royalties are equal or thereabouts, and the amount of rates paid by the bad colliery is equal to that paid by the good one. To this it may be objected that the same rents and royalties or thereabouts are paid, and the assessments are therefore made on the actual rents. The answer to that is: (1) Royalties are not rent, and they form no absolute measure of value as to rent; they are rather in the nature of a purchase of mineral, the consideration for which becomes payable when it is severed from the earth, and it then becomes stock-in-trade, and is no longer assessable for rating. (2) Coal-mines are nearly always leased for a period of years for better or worse, and the obligations under the lease have to be carried out, whether the mine works at a profit or not; but the rating valuation has to be based upon what a hypothetical tenant would give from year to year. The payments therefore which may have to be made under a lease, which may have turned out to be a bad bargain, can hardly be regarded as a fair test of actual annual value for rating.

It has been held that mines are exceptional cases, and ought to be valued on similar principles to railways, namely, by ascertaining the receipts, and then making the necessary deductions for expenses, tenants' capital, rents, rates, etc., the balance to be the nett rateable value.

In the case of the Denaby and Cadeby Colliery Company *v.* The Assessment Committee of the Doncaster Union, April, 1898,

the colliery-company put forward evidence that the best and only fair method of arriving at the nett annual value, was that of ascertaining the receipts of the year, and then deducting therefrom the proper deductions; in fact rating it like a railway. If this was admissible, it worked out substantially correct. It was contended that this evidence was not admissible, but that the colliery should be rated on the annual rent obtainable. Held, that the evidence was admissible; and held further, that where in a rate the gross and rateable value are entered at the same figure, the gross is to be treated as an ascertained figure, and such deductions as can be properly made may be made therefrom.

The arbitrator appointed by the Quarter Sessions was Mr. R. M. Littler, Q.C., and the questions he submitted for the Court, Queen's Bench Division, were:—(1) Is the evidence put forward by the appellants admissible? (2) Is the rent on lease, whether actual or estimated, under such circumstances binding, or any evidence in ascertaining the value for rating purposes? (3) Are the appellants, on such a rating as the three abovenamed, where the gross and rateable are entered at the same amount, entitled to claim to deduct from that gross as shewn in the rate-book, outgoings by whomsoever paid, and so arrive at the nett value, which in such case must necessarily be less than the gross?

DAY, J.—The first question, I think myself, is clear, that the evidence put forward by the appellants is admissible. What value the arbitrator will attach to it I am sure I do not know, but it seems to me it is clearly admissible. This is an exceptional case. There is nothing, he says, with which he could compare it. He knows of no collieries that are let by the year, and I suppose no one has ever yet heard of a colliery being so let. It is clearly an exceptional case, to be dealt with exceptionally. These rating questions are to be determined as nearly as possible correctly, and therefore, of course, in the most practical way that is available. It seems to me that this is a proper way of dealing with it. Then the second question is one which, by consent of counsel on both sides, has been disposed of already, and I do not think I need say any more about it. The third question is a question with reference to which, really practically, I do not see much difficulty. The gross has been put down, and I should assume that the figures have been arrived at rightly. I do not see how we are to get at the nett by going through the gross practically. I do not know that we can alter the words "gross" and "nett" in dealing with them in the ordinary way. I do not well see how you can proceed to arrive at the nett until you have found what the gross is. The gross I have always understood to be something from which you take off certain figures which you are entitled to take off. You get the gross first and then the nett. The gross is an ascertained figure which has been put by the parties as gross, and, having put it down, they must abide by it. I really do not see that we ought to interfere with it in any shape or way.

PHILLIMORE, J.—I am of the same opinion. I think it must be taken from the findings of the arbitrator that this colliery is such an exceptional colliery that the assessment can only be arrived at by the method applied to what are called "exceptional cases"; and therefore the evidence put forward by the appellants is necessarily admissible. The second question must be answered in the sense already indicated by the Bench, and now agreed upon in words upon both sides. With regard to the third question, I think the ratepayers are entitled to the benefit of the finding of the assessment committee as to the gross, and that the gross not being appealable from now, the nett must be worked out by making such deductions, if any, as are properly to be made from the gross. I propose, with my learned brother's consent, that we should answer question No. 3 in the way contended for by Mr. Cripps, that the appellants in such a rating as the three above named, where the gross and rateable are entered at the same amount, are entitled to treat the gross as an ascertained figure, and to make therefrom such deductions as they can support. We do not answer exactly the words of the question, because I do not want it necessarily to be assumed that there must be any deductions. Mr. Bosanquet has pointed out that there may be no deductions, and therefore the gross and rateable may be exactly the same.*

Subsequent to this Mr., now Sir E. Boyle, K.C., who had appeared for the colliery-company, read a paper before the Surveyors' Institution dealing with "The Rating of Coal-mines."† He dealt largely with the principle ruled to be admissible in this case, and urged that it was the only fair and just method of valuing collieries, and, to illustrate the case, he said:

The following is the form which a valuation of a colliery would, under this method, take, and the figures set out are practically those used in a somewhat recent case:—

Gross receipts from the sale of 581,713 tons of coal raised at pit in 1896	£165,991	
Less discounts and bad debts	613	
		£165,378
Deduct working expenses, including repairs, excluding rates and royalties	£138,067	
Less repairs	11,695	
		£126,372
Nett revenue and rates		£39,006
Occupier's share:—		
Tenant's capital £60,000, 20 per cent. thereon		12,000
Gross estimated rental and rates		27,006
Deduct rates		2,376
Gross estimated rental		£24,630

* *The Law Times Reports*, 1898, vol. lxxviii., page 389.

† *Transactions of the Surveyors' Institution*, 1899, vol. xxxi., page 143.

Brought forward		£24,630
Statutable deductions:—		
Repairs	£11,695	
Sinking fund to replace the landlord's plant in 30 years on 2¼ per cent. tables: £30,000 at 0·023, equals per annum	690	
Sinking fund to replace the shaft in 60 years on 2¼ per cent. tables: £40,000 at 0·0074 equals per annum ...	296	
		12,681
Nett rateable value of whole of the colliery		11,949
Less separately-assessed properties: washing-plant ...		600
Nett rateable value of colliery to be apportioned ...		£11,349

It should be observed, both as regards the quantity of the coal raised and the prices realized, and the discounts and bad debts, that they would all be actual figures taken from the books of the colliery. The working expenses also would be the actual money expended, and the same remark applies to the repairs. The tenant's capital would of course be the result of a valuation, and the interest thereon, which I think should be 20 per cent., is a matter for discussion and arrangement.

As regards the statutable deductions, although no objection could be raised to a sinking fund to replace the landlord's plant, there is some doubt whether the sinking fund to replace a shaft at the end of the time can properly be allowed, but on the whole I think it is an item the tenant should claim and receive.*

In the very interesting discussion which followed no objection was raised to the principle of taking receipts and expenditure into account, in arriving at the annual value, but some difference of opinion was expressed as to the difficulty of doing so, and the expediency or advisability of Government compelling colliery-proprietors to produce their accounts to Assessment Committees. There would, no doubt, in many cases, be serious ground for the objection, if no way could be found of obviating the necessity to produce the accounts to the committee in full.

Papers have also been read by Mr. G. Humphreys-Davies,† and by Mr. E. J. Castle, Q.C.‡ The former treated the subject from a surveyor's point of view, and practically argued that mines should be assessed like railways, gas-works, and other exceptional cases, namely, on profits. He, however, made one statement to which some exception can be taken, namely, "that

* *Transactions of the Surveyors' Institution*, 1899, vol. xxxi., page 154.

† *Trans. Inst. M.E.*, 1892, vol. iii., page 773.

‡ *Ibid.*, 1894, vol. vii., page 428.

the total value of the whole mine . . . must not exceed the total sum which a prudent tenant would feel himself able to give for the whole property on an average of years."* Now the law says nothing about an average of years; it says distinctly "from year to year," and referring to this point, Blackburn J. in R. *v.* Abney Park Cemetery Company, says, "The Act provides that no rate shall be allowed which shall not be made upon an estimate of the rent at which the hereditament might reasonably be expected to be let from year to year. In some cases perhaps it would have been better to have said 'to be let for a reasonable number of years,' but the Legislature has not said so."

Mr. E. J. Castle dealt with the matter more from a legal standpoint, but except on a question of rateability of tools, in the main he agreed with and supported the views of Mr. G. Humphreys-Davies and in the Denaby case it was held that their contention was correct, and their opinions were fully vindicated.

There is a general consensus of opinion amongst authorities on the question of rating-valuation, that mines ought to be treated as special hereditaments, and valued on a basis of receipts and deductions. The method would appear to be perfectly fair and reasonable, and any colliery labouring under great difficulties would automatically get relief without the trouble of appeal —probably to Quarter Sessions—the cost of which is so great that many collieries prefer to pay on what they realize is an unjust assessment rather than adopt the alternative. Of course it is conceivable, and, personally, the writer thinks very probable, that some collieries would get their present assessment augmented if profits were considered. If that were so, no one ought to complain. Money has to be obtained for these public purposes, and it is only fair that proprietors of highly profitable undertakings should contribute more than their less fortunate neighbours. They have to do so to all other taxation, and it is only when one comes to collieries that the illogical position is taken up, that valuation must be on the amount of output quite irrespective of annual values.

There is one other feature respecting local taxation involving, in the writer's opinion, frequent injustice to collieries, and this

* *Trans. Inst. M.E.*, 1892, vol. iii., page 775.

is in respect of district and special rates. The Public Health Act, 1875, sections 211 and 230, provides that for special works, the benefit from which is more of a sectional, than a general nature, such as sanitary schemes, etc., the assessment of railways, canals, agricultural land, etc., shall be only one quarter of the rate laid for that special purpose. This provision might with great justice be extended to collieries. A case came under the writer's knowledge where a colliery paid about one-fifth of the entire rates of a large parish. The colliery-property, which was not one-thirtieth of the parish-area, was in an extreme corner. An expensive sewage-scheme was adopted, which at no point of the parish, came within ½ mile of the colliery, neither did it anywhere touch one of the company's houses, of which they owned a large number. These facts were pointed out to the Inspector of the Local Government Board at the formal enquiry, and a special rating area for the purpose asked for. But the local authority, not one of whom was interested in the colliery, but were interested in the other property benefited, opposed, and asked for it to be charged over the whole parish. The Local Government Board ordered this to be done, and now the colliery is paying one-fifth of the cost of a scheme from which it does not derive one atom of benefit.

Assuming that some contribution should be made to improvements of this character, surely collieries should get the same relief as railways, farmers, etc., or a little justice should be observed by the local authorities, and the Local Government Board, a special area being defined, by which the beneficiaries of the improvements would be called upon to pay for it. This might also have the secondary effect of causing some schemes to be reconsidered.

Remedial Measures.

The writer thinks that no one will dispute the extraordinary state of confusion in respect of colliery valuations for rating, and he has endeavoured to state the facts as plainly as possible; but admitting the evil, we are still face to face with the difficulty of finding a just and suitable remedy. It is not an easy matter, and will open up a wide field for discussion before a generally satisfactory system is applied. The writer's own views are very strongly in favour of the application to collieries of the system

of receipts and deductions, as applied to railways and gas-works and other special properties, and he thinks that the objectionable feature of publicity can probably be obviated.

The Commissioners before referred to, in their final report, said:

> We do not think that it is desirable, or indeed possible, for us to make any recommendations with regard to the actual procedure which should be adopted in ascertaining the annual value of these properties. There must always be some difference of opinion among valuers on the question of what a hypothetical tenant might reasonably be expected to pay, but we think that it is of great importance that the valuation of these special properties should be centralized as far as possible, and undertaken by the most skilled classes of valuers.
>
> We are of opinion that the recommendation which we made in our First Report with regard to the constitution of the valuation authorities and the assistance of the representative of the Inland Revenue will secure greater uniformity in valuation in all classes of property. With regard to the special classes of property with which we are now dealing, *i.e.*, those which extend into several parishes, we recommended:—" That special properties such as railways, canals, mines, tramways, docks, telephones, and gas, water and electric light works, should be valued in the first instance by a valuer appointed by the valuation authority (that is, the county or borough valuation authority) objections being heard by that authority, and appeals lying to the Railway Commission or a special tribunal created for that purpose."
>
> As has been seen, after further considering the system of valuation in Scotland and Ireland, as well as in England and Wales, we have been led to propose a central system of valuation for railways; and with regard to these other special properties we are of the opinion that if the occupier of such properties, or the local authorities concerned, desire it, they should be able to have the properties valued by the Government Valuer of Railways instead of by the county or borough valuation authorities, and that an appeal should then lie to the Railway Commission or a special tribunal created for that purpose. If this was done, the parties would have the advantage of having the properties valued by experts accustomed to valuing the same classes of property in different parts of the country, who would have no local interest in the results of the valuation. When properties are valued in this way we think that the cost should be defrayed by those interested in the valuation.*

Following up this report, the Government, last year, introduced a Valuation Bill largely giving effect to the recommendations, making the valuation authorities the county and county borough councils, and calling in the assistance of the local Surveyor of Taxes, giving him discretionary power to alter the assessments on valuation lists if he did not approve, but still leaving the Quarter Sessions as the Court of Appeal. The Bill however, was not passed, and it met with very strenuous opposition from the existing rating authorities throughout the country.

* *Royal Commission on Local Taxation: Final Report of H.M. Commissioners appointed to inquire into the Subject of Local Taxation*, " England and Wales," 1901, page 62.

The change contemplated, of making the county and county borough councils the rating authorities, in lieu of the existing Assessment Committees, is very sweeping in character. Some considerable difference of opinion is bound to arise as to the wisdom and utility of calling in the services of the Surveyor of Taxes, practically to supervise the entire valuation lists for local taxation, and to alter any assessment which, in his opinion, requires alteration, even if in opposition to the views of the Valuation Committee.

But in whatever manner the details may be worked out, it is certain that great good will result from centralizing the operations, having periodical valuations, and some uniform scale of deductions, and if possible, simplifying and cheapening the machinery of appeal.

No doubt the Legislature will, in the near future, again endeavour to give effect to the recommendations of the Commissioners, and perhaps some good may arise from ventilating the question from the point of view of those interested in colliery-concerns.

The Chairman (Mr. W. N. Atkinson) said that nobody could live in these times without being aware of the great increase continually going on, both in local and Imperial taxation. He could understand that to colliery-owners it must be a very important subject, and from Mr. Hassam's paper he gathered that the method of assessment and other details of the subject were not in a satisfactory condition, and that there was room for improvement.

Mr. John Mayer said that he was satisfied that the method of making the assessment upon collieries was devised on a wrong basis. It was impossible to get any idea of the manner in which the assessment was arrived at: if they went to the parish-office, they were shown a book, and there was a certain amount entered against each colliery; and if they asked why it had been increased since the previous year, the parish-official answered, "Oh, I don't know; I am not in a position to say why." That was all the information that could be obtained. There was power of appeal, but it was no use for one person to appeal. If all colliery-owners united and tackled the question, they might get some consideration, and perhaps a reduction of the rates.

Mr. E. B. Wain remarked that the members were extremely indebted to Mr. Hassam for the thorough manner in which he had dealt with this subject, which was of considerable importance to collieries that were situated (as some in North Staffordshire were) in the immediate neighbourhood of large towns. When they considered that a colliery was assessed on what was considered by some people to be a rent, but was rather a payment for material removed from the property, there was not the slightest doubt that a grave injustice was done to the colliery-owner and proprietor. In working a man's property they were exhausting the *corpus*, and the payment in royalty, whatever it might be, was a consideration for the depreciation of that property. Therefore, it was not just that the property should be rated on a royalty-basis. Mr. Hassam, in dealing with the question of income tax, had omitted to mention the lack of allowance for depreciation. The man who invested his money in a colliery expected to establish a sinking fund to recoup his outlay when the colliery should be exhausted; but no allowance was made by the Income-tax Surveyors for the exhaustion of the property. All the profits were taxed, except a small allowance, perhaps, for depreciation on machinery. Colliery-proprietors spent the largest portion of their capital in making shafts and underground railways, and no deduction was permitted on account of this.

There was one point in Mr. Hassam's paper which might be misleading, and that was the amount of income tax paid on mines in ten years. There had been a considerable difference, in some years, in the amount of the income tax per pound, which would affect the comparison.

The Chairman (Mr. W. N. Atkinson) said that, judging from what one heard occasionally, the present practice of assessing mines gave general dissatisfaction. It rather appeared to be one of those things which was everybody's business, and therefore nobody was inclined to take it up thoroughly.

Mr. Hassam expressed his agreement with those who held that there ought to be greater allowances made for valuation.

The Chairman (Mr. W. N. Atkinson) moved a vote of thanks to Mr. Hassam for his paper.

Mr. J. T. Stobbs seconded the resolution, which was cordially approved.

THE MINING INSTITUTE OF SCOTLAND.

ANNUAL GENERAL MEETING,
HELD IN THE HALL OF THE INSTITUTE, HAMILTON, APRIL 13TH, 1905.

MR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The report of the Council was read as follows:—

ANNUAL REPORT OF THE COUNCIL, 1904-1905.

The Council have pleasure in submitting the twenty-seventh annual report, which is a record of a very successful year's operations.

The number of members on the roll at this date is as follows:—

Honorary Members	4
Life Members	10
Life Associate Member	1
Members (subscription £2 2s.)	164
Members (subscription £1 5s.)	265
Associate Members	25
Associates	14
Students	10
Non-federated Life Member ..	1
Non-federated Members (subscription £1 1s.)	13
Non-federated Members (subscription 10s.6d.)	6
Total ...	513

This number compares with that of last year as follows:—

On the roll at April, 1904		492
Added during the year		36
Total ...		528
Died	1	
Retired	5	
Cut-off through non-payment of subscriptions	9	15
At present on the roll		513

This addition is really due, not to a larger number of additions to the roll than last year, but to a smaller number of retirals.

The following papers read before the Institute during the year, with the discussions thereon, have been published in the *Transactions*.

"Notes on the Application of Electric Power at Mines in Germany." By Mr. E. O. Forster Brown.
"Winding of Minerals from Inclined Shafts." By Mr. Robert Crawford.
"The Occurrence of Calcareous Coal in a Lanarkshire Coal-field." By Mr. Robert W. Dron.
"Natural Coke in Douglas Colliery, Lanarkshire." By Mr. Douglas Jackson.
"An Inburst of Waste-water at Wallyford Colliery." By Mr. Robert Thomas Moore.
"Presidential Address" or "A Review of the Development of the Output of the various Scotch Mining Districts during the past 31 Years." By Mr. Robert Thomas Moore.
"Coal-mining in Borneo." By Mr. James Roden.
"Description of Houldsworth Colliery, Dalmellington." By Mr. William Smith.
"Fire in a Lanarkshire Colliery, and Description of a Condenser used thereat." By Mr. James C. Weir.
"Proposed Method of Sinking through Soft Surface." By Mr. James R. Wilson.
Discussion on the Working of the Champion Coal-cutter at Dalzell Colliery.

The Council invited the views of the members upon the Coal-mines Act (1887) Amendment Act, 1903, in reference to its effect on the qualifications of candidates for certificates of competency; and, in consequence of a discussion and resolution following thereon at the October General Meeting and published in the *Transactions*,* a memorandum was sent to the Home Secretary and to the Scotch Members of Parliament interested, with the view of influencing further proposed legislation on the subject.

The excursion in August, 1904, to the Houldsworth colliery of the Dalmellington Iron Company was a great success. The turn-out was large. The electric-power plant driven by a steam-turbine dynamo, a Riedler pump forcing against a head of 1,280 feet, the threefold longwall working, peculiar to that district, and a back splinting, 30 feet high, were features of special interest.

A visit was also paid in February, 1905, to the electrical

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 24.

engineering works of Messrs. Mavor & Coulson, Limited, Glasgow, where the members had an opportunity of examining coal-cutting machines on test.

A few additions have been made to the list of exchanges. The *Transactions* and periodicals received in exchange form an increasingly valuable addition to the library, and are accessible to all the members.

The donations to the library received during the year, in addition to those by exchange, are as follows:—

Donors.	Donations.
Mr. J. M. Ronaldson.	Mines Reports and Statistics for 1903, 3 volumes.
Mr. J. T. Robson.	Mines Reports, 1903, 1 volume.
Mr. Robert McLaren.	Mines Reports, 1903, 1 volume.
Colliery Guardian Company, Limited.	Annals of Mining and the Coal Trade, second series, by Mr. Robert L. Galloway.

The limited accommodation provided in the rooms of the Institute led the Council to look out for more commodious premises, and they are glad to state that a hall and ante-rooms have been secured in a building in course of erection in Cadzow Street, Hamilton, which will be ready for occupation by Martinmas next.

The Treasurer's accounts for the year shew the continued financial prosperity of the Institute.

There have been nine meetings of Council during the year.

The report was unanimously adopted.

The Secretary read the annexed abstract of the Treasurer's accounts for the year, which was adopted.

THE TREASURER IN ACCOUNT WITH THE MINING INSTITUTE OF SCOTLAND,
FOR THE SESSION 1904-1905.

RECEIPTS.			£	s.	d.
To Balance brought forward			494	11	3
„ Subscriptions—					
4 Members,	Session 1903-1904 ...	at 42s. 0d.	8	8	0
2 Members,	„ „ ...	„ 25s. 0d.	2	10	0
155 Members,	Session 1904-1905 ...	„ 42s. 0d.	325	10	0
249 Members,	„ „ ...	„ 25s. 0d.	311	5	0
12 Non-federated Members,	„ ...	„ 21s. 0d.	12	12	0
5 „ „	„ ...	„ 10s. 6d.	2	12	6
25 Associate Members,	„ ...	„ 42s. 0d.	52	10	0
12 Associates,	„ „ ...	„ 25s. 0d.	15	0	0
15 Students,	„ „ ...	„ 25s. 0d.	18	15	0
5 Members,	Session, 1905-1906 ...	„ 42s. 0d.	10	10	0
2 Members,	„ „ ...	„ 25s. 0d.	2	10	0
1 Student,	„ „ ...	„ 15s. 0d.	0	15	0
„ Rents of hall			12	18	6
„ *Transactions*, etc., sold			2	4	5
„ Interest on deposits			7	2	11
			£1,279	14	7

PAYMENTS.	£	s.	d.	£	s.	d.
By The Institution of Mining Engineers ...				478	1	2
„ Printing and stationery				37	19	10½
„ Books and book-binding				19	1	10
„ Rents of halls				29	16	6
„ Gas and assessments				5	16	2
„ Stamps, telegrams and carriages ...				11	4	8½
„ Sundry payments				2	17	1½
„ Expenses of Council				28	5	7
„ Cleaning halls				9	0	0
„ Salaries				96	8	0
„ Cash in bank	556	18	2			
„ „ in the Treasurer's hands	4	5	5½			
				561	3	7½
				£1,279	14	7

March 29th, 1905.—Examined, compared with vouchers, and found correct.

WILLIAM HOWAT
THOS. J. JAMIESON } AUDITORS.

Messrs. W. Howat and T. J. Jamieson were thanked for their services as auditors.

The following gentlemen were elected:--

MEMBERS—

Mr. WILLIAM F. ANDERSON, Claremont, Bridge of Allan.
Mr. WILLIAM COLQUHOUN, Manager, Carbarns Colliery, Wishaw.
Mr. JAMES EDMISTON, Manager, Dewshill Colliery, Forrestfield.
Mr. JAMES GAVIN, Udston Colliery, Hamilton.
Mr. DUNCAN LAMONT, Mining Engineer, 103, Watt Street, Glasgow.
Mr. DAVID MARTIN, Manager, Cambusnethan Colliery, Wishaw.
Mr. A. C. THOMSON, General Manager, Oakbank Oil Company, Mid-Calder.
Mr. JOHN WARDLAW, Colliery Manager, Carlew, Bellshill.

STUDENT—

Mr. JOHN P. KINGHORN, Anchorage, Burnside, Rutherglen.

ELECTION OF OFFICE-BEARERS, 1905-1906.

The PRESIDENT (Mr. R. T. Moore) declared the following office-bearers elected for the session 1905-1906:—

PRESIDENT.

Mr. ROBERT THOMAS MOORE.

VICE-PRESIDENTS.

Mr. JAMES HAMILTON.	Mr. ROBERT MCLAREN.
Mr. DAVID M. MOWAT.	Mr. THOMAS THOMSON.

COUNCILLORS.

Mr. THOMAS ARNOTT.	Mr. JAMES MCPHAIL.
Mr. HARRY D. D. BARMAN.	Mr. JOHN MENZIES.
Mr. ADAM BROWN.	Mr. T. H. MOTTRAM.
Mr. ROBERT W. DRON.	Mr. ROBERT A. MUIR.
Mr. DOUGLAS JACKSON.	Mr. J. BALFOUR SNEDDON.
Mr. HENRY KING.	Mr. THOMAS STEVENSON.

The PRESIDENT (Mr. R. T. Moore) delivered the following address:—

PRESIDENTIAL ADDRESS.

By ROBERT THOMAS MOORE.

I have once more to thank you for having done me the honour of again electing me President.

The Council's report shews that the Institute is progressing satisfactorily. The membership is increasing, and the finances are in a sound condition, so the Council have thought themselves justified in entering into a lease of a new hall which will give us more room than we have in our present somewhat cramped premises. Lastly, we have had several valuable and instructive papers read during the session, and this is really by far the most important part of the report, for the success of the Institute depends upon getting a plentiful supply of good papers.

There have been great advantages gained by federating with the other kindred societies, and that of getting copies of the papers which have been read before them during the year is not the least, but this embarrassment of riches is not without its disadvantages. It has been said that there is nothing new under the sun, and when all the mining intelligence of the United Kingdom is directed to submitting papers to a vast association such as that to which we have the honour to belong, the old mining problems are very soon disposed of, and anyone wishing to read a paper feels that he has very little choice left in selecting a subject. Some of our younger members, too, are perhaps a little diffident about bringing a paper before so large an audience. This should not deter them; they should remember that all the benefit from a paper is not got by those to whom it is read. "Reading maketh a full man, but writing maketh an exact man," and a member greatly instructs himself by writing papers.

There are many subjects of local interest which should be discussed. Many of our ways of overcoming difficulties are

different from what is done in other districts, and it is only by putting all of them on record and having them fully discussed that the best can be found out and adopted. Successful colliery management is largely a matter of careful attention to details, and nothing is so insignificant that it should not be attended to and done in the best possible way.

There are many details of the management and arrangements of collieries about which papers can still profitably be read. We do not appear to have had a paper with drawings of a large pumping-fitting, with the methods of fixing the pumps in the shaft. These arrangements have been considerably improved in recent years, longer lifts have been applied, iron has been more largely used in the pit-work, the pump-valves have been put out of the shafts, and many other improvements have been introduced. The alterations have all been adopted one by one, and it is only by comparing a pumping-fitting of, say, thirty years ago with one of the present day that we see how many improvements have been made. It is all the more necessary, therefore, that papers should from time to time be read putting the improvements upon record. We get drawings of pumping-engines and pumps, but how seldom do we see detailed drawings of the pit-work, with the method of fixing the pump in the pit, collaring the rods, and the many other details of pump-work! Probably it is because the former work is done in a mechanical engineer's shop where everything is made to a drawing, and the latter is still largely done without complete drawings being made. But this is not as it should be; there is just as much advantage to be gained by having drawings of what is to be done in the pit, and making the work to them, as there is in making an engine to the drawings.

Then, although we have had descriptions of sinking through difficult surface, we do not appear to have had any description of an ordinary sinking, and there are many features in our Scotch practice worthy of being put on record. We have had many improvements in sinking—the employment of rock-drills and the use of high explosives, the improvements in sinking-pumps, in the methods of walling, and in the methods of taking away the débris from the sinkers. There is still room for much improvement. We all of us know that in all our arrangements the only men usefully employed are the dozen men or so who are working in the bottom of the shaft, and our pumping and winding

machinery and other appliances are only oncost to enable these men to be kept working there. And, in sinking, by far the greater part of the expense is this oncost, the actual cost of removing the rock being only a small proportion of the expense of sinking. It, therefore, behoves us to apply every means, mechanical or otherwise, to render the labour efficient at the point of attack.

Sinking is one of the mining operations to which we have not yet been able to apply machinery satisfactorily. No doubt it is thirty years since the Kind-Chaudron mechanical system of sinking was tried, but the arrangement was costly and has only been used on special occasions.

Perhaps we should attack the problem from a different side. We put down a diamond bore-hole entirely mechanically. It is a big stretch from a bore-hole 12 inches in diameter to a shaft of 20 feet, but it would certainly be a great advantage if we could sink a pit as a diamond bore-hole is made. Some improvement in our methods is certainly a subject well worthy of study; and it is of special interest in Scotland, where we are likely to have more deep sinkings in the future.

The most valuable contribution to mining knowledge within the year has been the report of the Royal Commission on Coal-supplies. It is of special interest to our Institute, on account of the association with it of our past-President, Mr. James S. Dixon, whose masterly report on the Scottish coal-fields sums up all the available information on the subject and will long be a classical work of reference.

The report itself, with the detailed reports on the various districts and the evidence of the witnesses, forms a complete record of the most recent knowledge on mining. There is hardly a question which has not been fully dealt with by one or other of the witnesses, indeed, it may be said to be a complete text-book on mining.

It is comforting to think that there are still to be worked in this country more than 100,000,000,000 tons of coal, or over 400 years' supply at the present output. Oddly enough, the increased quantity of coal over that calculated by the Royal Commission of 1867, almost exactly bears out the remark made by a former president of the Institute, the late Mr. Henry Aitken, that, if a commission were appointed to calculate the amount of

coal-resources every thirty years, each one would give an increase in the quantity of 10 per cent., and that, notwithstanding the quantity of coal worked between commissions. One hesitates to suggest that the next commission, of, say 1940, may give an increase of 10 per cent. over the present quantity, though the Royal Commissioners have explained that the increase is due to exploration having proved the existence of additional areas containing coal and more accurate knowledge of the coal-fields; and it is not impossible that there may be sufficient evidence available at the time of the next commission to render the prophecy correct.

Fully one half of the total increased quantity of 10,750,000,000 tons seems to have come from Scotland, and there, the increase has been got in Edinburgh, Lanark, Fife, Stirling and the Firth of Forth, there being a decrease of 770,000,000 tons in Ayrshire. In England, there is a large decrease in the estimated quantity in the South Wales coal-field and a large increase in the Midland counties.

One can but echo the satisfaction of the Royal Commissioners when they state that over 79·3 per cent. of the available resources are contained in seams over 2 feet thick and upwards.

The Royal Commissioners have, wisely perhaps, not predicted the rate of output for the future. The former commission made estimates, and though the estimate given of the total rate of increase has been much exceeded, this has been due to the great increase in the export of coal, a trade which has assumed an enormous importance since 1871. It is interesting to note that their estimate of the portion of the output which would be used for home consumption is almost correct. This is the more curious as their calculations were based upon the estimated increase in population and the estimated consumption per head, and both estimated figures were wrong, the estimated population being too small and the estimated consumption being too large, nevertheless the two errors nearly balanced each other, the figures for 1901 being: —

	Population.	Consumption per Head. Tons.	Home Consumption.
Estimated	35,087,000	4·6286	162,400,000
Actual	41,544,145	3·8820	161,263,869

The estimated average over the twentieth century of an annual export of 12,000,000 tons, fell far short of the actual export for 1901 of nearly 58,000,000 tons. The figures are merely

an additional argument, if such were needed, to enforce the wellknown maxim as to the difficulty of prophesying. In the face of this warning it may be somewhat presumptuous to suggest a doubt as to the correctness of the Royal Commissioners' view that at a time, not far distant," the rate of increase of output will be slower, to be followed by a period of stationary output."* While there is no doubt that the output cannot go on increasing indefinitely, I should be inclined to put the time when the increase will cease farther off than is indicated by the phrase in the report, for it seems to me that the output depends more upon the demand than upon anything else, and if the prosperity of the country goes on and the export trade is not hampered by artificial restrictions like the coal tax, more coal will be wanted; and, if more coal is wanted, means will be found to overcome the difficulty in raising it, and more coal will be got.

The recommendations of the Royal Commission with regard to coal-cutting, preparation and cleaning of coal, and coking, and economies in its use, are worthy of the most careful study on the part of all connected with mining. The use of coal-cutting machinery has been carefully studied in Scotland, disc-machines having been in use in longwall workings in the East of Scotland for over thirty years. There are now many thin seams being worked by their aid which could not otherwise be profitably worked.

In coal-cleaning and coal-washing machinery, Scottish collieries are as well equipped as those in any district in the United Kingdom. The recovery of bye-products has also been carefully gone into at the Scottish blast-furnaces. There are, too, bye-product coking ovens, though the quantity of coal suitable for coking in Scotland is too small to make the subject of so much importance as it is in England.

The economy of fuel at collieries is a point, which, I am afraid, is not sufficiently studied. It is true that much of the coal used at collieries is of inferior quality, but this is a small excuse. It is only a short time since dross was considered of no value at Lanarkshire collieries, and now, by washing, it has been rendered suitable for market. We should endeavour to save as much coal as possible, and then try to find some method

* *Final Report of the Royal Commission on Coal-supplies*, 1905, part i., page 6.

of treating the coal saved which would enable it to be sold. It is somewhat striking to think that the 18,000,000 tons of coal used in British mines is more than half of the total output of Scotland, and it is nearly a half more than all the coals used on British railways; it is more than all the coals used in making gas, and it is more than half as much as all the coal used in domestic fires. These are striking figures, and if it be the case, as one witness said, that by better appliances, half of this quantity could be saved, the comment of the Royal Commissioners that the subject is worthy of the attention of colliery managers is much to the point.

It is worth considering whether some application of gas-firing plants, with recovery of ammonia, should not be adopted. With Mond gas as much as 80 pounds of sulphate of ammonia per ton of coal is being recovered, and this (at present prices) represents a value of 6s. to 7s. a ton. This means that British collieries are blowing into the air over £5,000,000 worth of ammonia. No doubt there are difficulties in the way of getting suitable producers, and there is the cost of the plant necessary for dealing with fine coal, but the subject is well worthy of consideration.

Much might be done by central electric plants supplying power to drive machinery, instead of the small and wasteful engines employed at collieries. We have had a description in the *Transactions* of the successful application of an electrical plant to an oil-work and mines at Niddrie Castle. This is a step in the right direction, and Mr. E. O. Forster Brown's paper gives us a description of what is being done in Germany. I am afraid that we are somewhat behind the Continent in this matter. There is no doubt that the application of electricity to mining has been one of the most important improvements within the century. With the facility which it gives for carrying power into the workings, I am inclined to think its importance second only to the introduction of the steam-engine.

In this connection great economies could be effected by combination among collieries in districts. Take the Edinburgh coal-field, which is being so extensively developed at present, as an instance. All the larger collieries are within a radius of 5 miles, and it would be quite possible to put down a large electric installation in the centre to supply electrical power to them. This

could be fitted with the most economical machinery, and would be on such a scale as to make it profitable to employ gas-engines with plant for the recovery of ammonia. There need be no boilers at the collieries, all the plant being worked electrically. With such an arrangement large economies might be effected. Possibly the electric-power companies whose works are now being erected may be able to supply power cheaply enough to enable it to be used at the collieries, although the prices which they have been proposing to charge would require to be much reduced before it would be profitable to do so. The large quantity of power required and the steady demand, should enable them to lower the costs of production, and if electricity can be sold at anything like the cost of manufacture indicated by the Royal Commissioners (0·13d. per kilowatt-hour) there should be a large use of it at collieries.

I am not sure whether in the past Scotch coal-owners have not been too reluctant to join with one another in carrying out arrangements which would be mutually beneficial. There are many cases where joint arrangements for pumping, for working, screening and washing coal might have been made with economy.

The suggestion of the Royal Commission as to the collection of records of bores is a very valuable one, and it is worth considering whether the Institute might not do something in the matter. No doubt there might be some reluctance on the part of coal-masters to give information as to the result of bores which have cost a good deal of money to put down. Yet we have the example of the North of England Institute of Mining and Mechanical Engineers which has published several valuable volumes containing records of borings in Northumberland and Durham. Might not our Institute undertake a similar task? No one would be better able to see it properly carried out than our Secretary, Mr. James Barrowman.

The portion of the *Report* dealing with the progress made by our competitors in the coal trade—Germany and the United States—cannot fail to be of interest to us. It shews that, since 1870, the output of Germany has increased more than four-fold —being in 1901, 153,000,000 tons, and that of the United States no less than ten-fold—being in 1901, 266,000,000 tons—while

the output of the United Kingdom has only doubled, being in 1901, 222,000,000 tons.

In a report to the Commission by Mr. Bennett H. Brough there is a very interesting table shewing the coal-resources of the United States and the chief European countries published in 1893 by Mr. R. Nasse in a report to the Prussian Government. It is as follows:—United States, 684,000,000,000 tons; United Kingdom, 198,000,000,000 tons; Germany, 112,000,000,000 tons; France, 18,000,000,000 tons; Austria-Hungary, 17,000,000,000 tons; and Belgium, 15,000,000,000 tons. These figures may not be exactly correct. They are not, so far as the United Kingdom is concerned—but taking them as shewing the proportionate quantities and dividing them by the outputs for 1903, we see that the various coal-fields would supply these outputs:—United States, for 2,120 years; United Kingdom, 860 years; Germany, 700 years; France, 530 years; Austria-Hungary, 425 years; and Belgium, 650 years. It is again comforting to consider that Great Britain's coal-supply will last as long as that of her Continental rivals. It appears as if it would last longer than that of Germany where the output is increasing at a faster rate than in Great Britain, and if the output progresses in the United States at the rate at which it has been going for the last few years, our descendants may even enjoy the luxury of a coal-fire when that is not to be had on the other side of the Atlantic. Even when the British coal-fields are exhausted, the world will not be without coal, for China contains an area of 232,000 square miles (as against the United States, 200,000 square miles, and Great Britain, 12,000 square miles) out of a total of 800,000 square miles, which is estimated to be the total area of the coal-fields of the world.

DISCUSSION OF MR. JAMES RODEN'S PAPER ON "COAL-MINING IN BORNEO."*

Mr. ARCHIBALD RUSSELL (Newmains) submitted a few data noted whilst he was on the Gold Coast in 1902 and 1903. The observations were taken at a gold-mine, situated about the same latitude as North Borneo, namely, 7 degrees north of the Equator,

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 236; and 1905, vol. xxix., page 36.

where a somewhat similar enervating climate exists. The ventilation is natural, and, owing to the presence of steam-pipes and pumps in a vertical shaft, 210 feet deep, it is the upcast shaft. The principal downcast shaft is an inclined shaft, 240 feet deep, with a winze at the bottom, 70 feet deep. A steam-pump is working in the bottom of the winze. The temperature-observations were as follow: In the sun, 107° Fahr.; top of downcast shaft, 91° Fahr.; No. 1 level, 70 feet vertical, 93° Fahr.; No. 2 level, 160 feet vertical, 94° Fahr.; No. 3 level, 240 feet vertical, 95° Fahr.; No. 4 level, 310 feet vertical, 105° Fahr.; at pump, 300 feet vertical, 110° Fahr.; and top of upcast shaft, 112° Fahr.

DISCUSSION OF MR. E. O. FORSTER BROWN'S "NOTES ON THE APPLICATION OF ELECTRIC POWER AT MINES IN GERMANY."*

Mr. ROBERT CRAWFORD (Loanhead) wrote that Mr. Brown touched a very important point, when he spoke of reducing the cost of several separate boiler-plants by transmitting electricity from a main central station to work machinery at outlying shafts and using coal of very little value and often unsaleable at the station. The question might be asked: Does this system pay? So far as has yet appeared any lack of commercial success has been due to other causes than the cost of electric transmission, in fact, judging from nearly all of those which have been running long enough to draw any conclusions, experience has said "centralize." Transmissions of large magnitude have been derived from water-powers, and it is singular to note how their success has stimulated their production; but sooner or later something must be done with seams of coal untouched as yet because of their poor quality. The transportation of coal is a special case of the transmission of energy, and it may with perfect fairness be compared with electrical transmission. Coals have varying values as fuel, while the cost of mining and transportation are fairly uniform. Hence, any examination of the question, just raised, must take the difference into account. The first thing to be done in studying the problem of the transmission of power from cheap coal at the mines is to get at some common basis of comparison, between carrying the energy in bulk and sending it

* *Trans. Inst. M.E.*, 1905, vol. xxix., page 40.

over a wire. Taking the ordinary distribution of power through a city, experience has shown that there is a gain in generating it in large quantities and distributing it electrically in the ordinary small industrial units. Knowing that a large central station can distribute power economically, can it the more cheaply generate it by coal burned on the spot, or by power transmitted from a region of cheaper coal? A common unit can be obtained in the following way: A good compound-condensing-engine is capable of producing 1⅓ horsepower-hours, that is, 1 kilowatt-hour by the consumption of about 2 pounds of good coal. Whether the coal or the current be transmitted, the engine will be used, so that, for a rough approximation to the economies of the matter, the cost of the electrical transmission per 1,000 kilowatt-hours need only be compared with the expense of freighting and handling 1 ton of coal. The cost of transmission means simply the interest, care and depreciation on the electrical portion of the total plant. The cost of line and apparatus for a 50 miles 15,000 volts transmission in large amount may be reckoned at something like £20 per kilowatt transmitted. Taking interest, labour and maintenance at 20 per cent., and assuming 3,000 working hours per year, the charge for transmission becomes 0·3d. per kilowatt-hour. This is high freight-weight for the distance. It is therefore evident that with good coal, transportation can more than hold its own against electrical transmission. On the other hand, the transportation under certain circumstances may be so expensive as to throw the balance the other way. In some mining districts, where fuel has to be conveyed for miles over mountains, an electrical transmission, as indicated, might pay handsomely. There is also another side to the question: in all mining there is produced a varying proportion of coal which is unfit for transportation and sale, and also, as previously mentioned, seams of coal lying untouched because of poor quality. The competition is not here between freightage and electrical transmission, but between power produced from coal costing 12s. to 16s. per ton and coal costing 1s. or 2s. per ton. The latter may be poor indeed, but still it is cheap fuel, and if it can be utilized to generate power for 24 hours a day the charge for transmission, *plus* the cost of fuel, may fall so low as to be below the fuel-cost at some outside point under consideration. For instance, the

charge of 0·3d. per kilowatt-hour, previously computed, may readily sink to 0·2d. at a more moderate distance. At this cost, it would come into active competition with power produced on the spot, even with fairly cheap coal and good engines. Taking into account the cost of a moderately long transmission, it seems probable that, including the loss of efficiency in transmission, one mechanical horsepower-hour could be delivered anywhere within, say, a radius of 20 miles at an actual cost of 0·25d. The economy of such a plant is based both on cheap fuel and a large and relatively continuous service. Another and equally interesting field for transmission on a large scale, lies in the existence of coal of poor intrinsic quality, which stands shipment poorly, being too soft and friable. Such coal can, and does, often exist in regions where good coal is expensive. In this case, the ability to substitute cheap for costly fuel is quite sufficient to overcome the cost of even a long electrical transmission. It may pay to carry the power even 50 miles. While coal is plentiful, the temptation to work in the direction of colossal transmissions from cheap coal is partly removed. Yet it should not be forgotten that coal ought never to be cheap enough to throw away, and wherever cheap coal is available it deserves to be thoroughly investigated, with reference to the possibility of electrical transmission. The larger the plant and the steadier the service, the greater the distance over which power can be sent to compete with that generated on the spot. Pressures of 25,000 or 30,000 volts are practicable; while the feasibility of covering greater distances at higher voltages is more or less a matter of speculation.

Mr. John F. Balfour (Portobello) wrote that he was surprised to learn that Mr. Brown questioned the reliability of gas-engines. There are now several gas-engines that develop 2,000 horsepower each, using natural gas, and giving entire satisfaction; and there are thousands of smaller power, working without a word of complaint. It may be that the difficulty encountered in Germany has been with the valves sticking, caused by use of dirty gas, and, no doubt, gas derived from coke-ovens would be rather difficult to make sufficiently clean for use in gas-engines. He (Mr. Balfour) had seen a gas-suction plant in the city of London, which had been running for consider-

ably over a year and had never given the slightest trouble, other than the cleaning of the valves once in the three months. Gas-engines of a good maker were reliable. An ideal plant on a mine would be gas-engines, using gas from coke-ovens, generating electricity.

He (Mr. Balfour) agreed with Mr. Brown when he stated that the centrifugal pump was the "pump of the future." The following are particulars of a centrifugal pump at present working in the Midlands: it is driven by three-phase current, at 490 volts and 98 ampères and 1,160 revolutions per minute. It is pumping 28,000 gallons per hour through pipes, 6 inches in diameter, to a vertical height of 284 feet. The efficiency was 66 per cent. of the power put into the motor. No doubt a triple-expansion condensing-engine would yield an efficiency of 70 to 75 per cent., but it need not be stated that there are difficulties and dangers in connection with long lines of steam-pipes, joints, packing, valves and wearing parts. The electric plant had been lately duplicated: a good recommendation. Two points in working centrifugal pumps are worth mentioning, namely: the suction-pipe cannot be too large; and sufficient means must be provided to prevent air from collecting at the top of the casing, as these means are not always provided by the makers.

The description and details of the pumping-plant at the Victor colliery* deserved to be studied by all who had anything to do with the erection of pumping-plants, especially those who had to pay for them. No details as to the efficiency of the steam-engines driving the dynamos had been given. It might be of interest to know that, at one colliery in England, a Parsons steam-turbine, coupled direct to a dynamo, had been working alongside, under the same conditions, a vertical triple-expansion condensing-engine, both being of 400 horsepower. After three years' experience, the triple-expansion engine was being replaced by another turbine. The present turbine had not cost a penny for repairs, and with steam at a pressure of 120 pounds per square inch, the consumption of steam was 16 pounds per indicated horsepower-hour. The rate of steam-consumption, taken along with the simplicity of the engine, few working parts, the small repair-bill, light foundations and the reduction of weight per indicated horsepower, stamped the turbine as the coming steam-engine.

* *Trans. Inst. M.E.*, 1905, vol. xxix., page 44.

Mr. T. Lindsay Galloway (Glasgow) said that he did not think that Mr. Brown had mentioned the number of periods per second, which at the present time, was generally used in Germany for alternating current. This was a question that was of some interest, and he trusted that Mr. Brown would be in a position to supply the necessary information. No doubt, for lighting purposes, it was not advisable to go below 40 or 50 periods per second, but nowadays, when large plants were being erected for power-transmission, lighting was a matter of secondary importance, and a frequency of 25 periods per second might be considered suitable where large motors had to be driven at a comparatively low speed. In such a case, it might be advisable (and no doubt it was) to use a continuous-current dynamo to excite the field-magnets of the alternator, with sufficient surplus power to do the lighting or any other continuous-current work. He (Mr. Galloway) agreed with what Mr. Brown said regarding the superiority of three-phase current for power-transmission. Mr. Brown's remarks with regard to the efficiency of three-phase motors might give rise to misconception. A three-phase motor was designed to run at a particular speed, and if it ran at that speed, its efficiency at three-quarter load, or half-load was very high. The case to which Mr. Brown specially alluded was that of a three-phase motor running at a speed to which it was not adapted. In that case, there was an immense loss, but that should not be confused with the case of a motor running under less than full load, at its proper speed. Mr. Brown gave an interesting account of the pumping-plant at the Victor colliery, where a large quantity of water was raised by means of centrifugal pumps. No doubt, the old type of centrifugal pump was not adapted to high lifts, but, of later years, many improvements had been made upon it, especially in providing guide-blades for reducing the velocity of the water. Indeed, makers now claimed that centrifugal pumps had attained an efficiency which was comparable to that of reciprocating pumps. He (Mr. Galloway) had not himself had any experience with them, but he hoped very shortly to have an opportunity of comparing a centrifugal pump, direct-driven, with a triple ram-pump driven by gearing. Mr. Brown also in the course of his paper mentioned that some reciprocating pumps were being used, in which the motion was derived direct

from the motor without gearing. It would be interesting to know at what speed these pumps were driven, what kind of motors were employed, and especially the number of poles with which these motors were provided.

Mr. H. D. D. Barman (Glasgow) said that Mr. Brown dwelt entirely with new collieries which were completely fitted up with electrical appliances. This was all right for such collieries, but in Scotland, where the collieries were already fitted out with steam-plants, electricity would only be adopted in the case of additional or replacement plants, such as pumping, ventilating, etc. For these, a good use might be made of the Rateau steam-accumulator, consisting of a set of trays filled with water into which the exhaust-steam from the winder was passed, the water in the trays thereby absorbing heat, the excess steam being passed to a low-pressure turbine and condenser, then after the winding-engine had finished, vapour still came off the water that was contained in the trays, thereby keeping the turbine working during the cessation of winding.* This was one method that might be found suitable for use at small collieries, where they could not join with others in arranging for a big central station. Mr. Brown also mentioned air-compressors, producing air at a temperature of 102° Cent.; but he (Mr. Barman) submitted that it was not an excessive temperature; and with efficient intermediate coolers between the low-pressure and high-pressure air-cylinders, also by making sure that the free air is drawn from a cool place and not from a hot engine-room, there ought to be no difficulty. It is seldom realized what a difference the colder air will make. In one case, where the air was drawn from a very hot engine-room, the final temperature was so great that the oil deposited carbon in the lubricator-pipes; and in another case, distinct advantage was found in drawing the air from the north side of the engine-room where there was constant shade.

Mr. James T. Forgie said that he had lately had occasion to consider the question of pumping; and he had heard about centrifugal pumps and the work that they were doing on the Continent. His information as to their capability was very much

* *Trans. Inst. M.E.*, 1902, vol. xxiv., page 322.

to the same effect as that mentioned by Mr. Brown. He got quotations for a centrifugal pump, and the manufacturers also gave him the names of people who were using it. He wrote to one of the firms named asking permission to see the pump at work, and at the same time requesting their views as to the durability and capacity of the pump for the work in hand. The reply he had was to this effect, that the pump was simply a stand-by one, and, so far as they could judge, would not be anything else. Personally, he was disposed to think that experience on the Continent in sinking with centrifugal pumps had been very limited indeed. He thought that, if they were sinking a pit, where a great deal of fine sand was drawn through the centrifugal pump along with the water, the life of that pump would be short. In two years' time, he believed that the pump would require to be replaced by a new one, or supplied with a new lining and a new vane. That was his impression, and it was based on information supplied to him by a user of the pump. He was told that they would never contemplate using the pump for continuous working. There was no doubt, however, that this type of pump had been used on the Continent for a short time, and up to the present it had done splendid work.

Regarding the Rateau accumulator, to which Mr. Barman had referred, he might say that he had had occasion to read a paper on this subject by Mr. Rateau. It seemed to him, so far as he could see, that if they would apply an ordinary air-pump and condenser to winding and other colliery-engines, there was no saving to be derived from the Rateau accumulator. It was altogether very complicated, and he was not much impressed with it. Where a condenser could be applied to an ordinary winding-engine and there was plenty of water, he thought that quite as much economy could be gained as with the Rateau accumulator.

Regarding the whole question of using electricity in mines, he thought that it was a very serious matter for coal-masters to think of altering their plant. In fact, before they could be induced to change their plant from steam to electricity, it would require to be conclusively demonstrated to them that they were changing in the right direction. In his (Mr. Forgie's) opinion, it was very questionable whether or not they would be changing in the right direction. Perhaps in a new district, where it was

proposed to lay down several collieries, the establishment of a central plant might be considered an advantage, but the economy was not in simply centralizing the power. He believed that a number of smaller plants at individual collieries were just about as economical, when everything was taken into consideration, as a large central generating-plant distributing power over an area with a radius of 2, 3 or 5 miles. One great advantage in a central plant, and the only advantage to his mind, was that they could make arrangements for thorough economy in fuel. A slight mention of this economical use of fuel was made in the paper contributed by Mr. Brown. The fuel was converted into gas, and used in gas-engines for driving at the generating-station. There were various methods of using it. For instance, there was one method by which ammonia as well as producing power could be taken from the coal. In this way, infinitely more profit was got from the fuel than by burning the whole underneath the boilers. A strong argument, which was used in favour of establishing central plants, was that, at individual collieries, they were meanwhile consuming coal that might be sold. In Lanarkshire, especially, he (Mr. Forgie) thought that there was very little coal consumed which could be sold to much advantage. True, they might get a little more out of it than at present; but to his mind, unless the prices were very substantial, the benefit would be practically of little use. The great economy, if there were to be central plants, lay in consuming the coal in a thoroughly economical manner, by converting it into gas to drive the gas-engines and, thereafter, driving the generating-plant from the gas-engines. With such small fuel from the washeries, as was used at a large number of the Lanarkshire collieries, it would be very difficult to work gas-producers at a central generating-station. If a better quality of fuel had to be used there could be no gain.

Mr. Robert McLaren (Edinburgh) said that coal-masters in the east of Scotland were evidently not of the same opinion as Mr. Forgie. A very large installation for a central plant was being erected in the neighbourhood of Dunfermline, and a number of coal-masters were meanwhile waiting to obtain power to drive pumps by electrical means at their various pits. Evidently, Fife coal-masters believed that it would be a saving and to their ad-

vantage to take power from a central station. It might interest the members further to know that they were about to erect at the Tarbrax mines, near Cobbinshaw, the first electrical winding-engine in Scotland. The generating system would be the same as that adopted at Niddrie Castle, Duddingston: the power being centralized at the works, and thence, cables would be led to the various mines. He (Mr. McLaren) agreed with Mr. Forgie that it would be a serious matter for a coal-owner with a large fitting for steam, to consider the question of substituting electric plant for it. It seemed to him that electricity would be the power of the future, and the right way was to produce it at a central station.

Mr. T. H. Mottram asked as to the kind of cable in general use at the places visited by Mr. Brown; whether three-cored in the case of three-phase, or single cables were used; and as to the sort of insulation found safest and most durable under the variable conditions that existed underground.

The President (Mr. R. T. Moore) said that in Scotland, central electrical installations had been applied to oil-works where, as the fuel had to be purchased and was costly, any saving was of more importance than at collieries where the fuel was only the refuse which in many cases could not be sold.

It was so short a time since electrical plant was first introduced at collieries, that the application might be said to be only in its infancy; and, very soon, there might be sufficient experience accumulated to overcome the numerous difficulties which attended its more extensive use. There were several objections to the introduction of gas-producers, concerning which mention had been made. One great difficulty was in finding a gas-producer suitable for using small coal. Fine gum-coal from the washers was hardly suitable for that purpose, but it contained a high percentage of coal. If it could be used, if a large quantity of ammonia could be recovered, and if the gas could be used for driving gas-engines, then the question of central plants might assume a different aspect from what it did at present. He had no doubt, when they had had more experience, and had become familiar with the different details of electrical and gas-producing plants, that some method would be discovered by which small coal could be utilized.

Mr. James Morton said that a Rateau steam-accumulator and an exhaust-steam turbine-plant was about to be erected in Scotland. This plant would be worthy of the notice of the members, as it was designed to be operated by the exhaust-steam from engines working intermittently, and colliery winding-engines were necessarily of this class.

The discussion was adjourned.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE QUEEN'S HOTEL, LEEDS, JANUARY 24TH, 1905.

MR. T. W. H. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

MR. HENRY BLEWITT, Underground Manager, c/o Messrs. Arnholder, Karberg & Company, Hankow, China.

MR. GEORGE AULD LEITCH, Colliery Manager, Pelaw Main, *via* West Maitland, New South Wales.

ASSOCIATE MEMBERS—

MR. WILLIAM ROBINSON, 76, Clarkehouse Road, Sheffield.

MR. CHARLES BLADES COVERDALE STOREY, Lancaster.

ASSOCIATES—

MR. ROBINSON EASTWOOD, Under-manager, Lyndhurst, Crigglestone, near Wakefield.

MR. TOM FEARNLEY, Under-manager, 1 Dawgreen Avenue, Crigglestone, near Wakefield.

Mr. W. H. PICKERING's paper on "The Dust-danger" was read as follows:—

THE DUST-DANGER.

By W. H. PICKERING.

The importance of dust, as a factor in colliery explosions, is now so generally recognized and understood that there is no need to sketch, even in outline, the dangers which are inherent in it. The Royal Commission appointed to consider the dust-danger in mines issued a very valuable report, and it has also been the subject of many papers read before mining engineers. The practical result, so far, has been the introduction of provisions in the Coal-mines Regulation Acts regulating the use of explosives in dry and dusty places, and the issue of the Explosives in Coal-mines Order by the Home Secretary. In a few mines, dust is systematically laid by watering, but no widespread effort has been made to strike at the root of the danger.

Permitted explosives are only relatively safe, for each one of them is capable of initiating an explosion under certain conditions, and it cannot be too often repeated and emphasized that a dust-explosion can be started in other ways than by an explosive. For example, an ignition of fire-damp may result from a naked light, from a damaged or defective safety-lamp, from a spark from a pick or from an electric spark, and this may be magnified by dust into a great explosion.

Dust also greatly increases the danger of underground fires. A few examples may be given to show how easily coal-dust can be ignited in favourable conditions. In a Lancashire colliery, sparks, from the brake-rim of the drum on an inclined plane, fired the dust lying on the floor; a fireman happened to be within 50 feet of the place, but before he could reach it there was a ball of fire as large as two fists in the dust; a bucket of water was dashed on it at once and the fire spurted in all directions; but it was soon extinguished. At a Yorkshire colliery, similar sparks, from a brake-rim, fired the dust deposited on the bars of a main haulage-road and there was a slight dull

explosion. At another Yorkshire colliery, the dust inside a hollow pulley carrying the tail-rope of an intake haulage-road took fire from the friction of the spindle, and a most serious fire would have resulted, if a deputy, who chanced to be travelling out-bye, had not extinguished it.

Obviously the only radical way of remedying the danger is to keep the mines free from coal-dust by cutting off the supply, or by other means. One may therefore consider:—(1) What are the chief sources of dust in mines? (2) where is it most dangerous? (3) present or suggested methods of dealing with it; and (4) practical difficulties to be overcome.

(1) *Chief Sources of Coal-dust.*—A little coal-dust is made at the working-faces in the process of coal-getting, and some is shaken from the tubs on the tributary roads. In main haulage-roads and in the winding shafts, the dust is shaken from the tubs or is swept off them by the air-current during their passage. The full tubs usually meet the air-current, and in mid-shaft it often passes them with great violence, as the speed of the cages in mid-shaft in some deep mines varies from 40 to 50 miles an hour. A considerable quantity of dust is carried down the shafts from the screens by the intake-air.

(2) *Where the Dust is Most Dangerous.*—The dust at the coal-face and on tributary roads is usually mixed with stone and fire-clay dust, and is thus rendered somewhat less dangerous. There is not often much coal-dust in return-airways. The greatest danger lurks in downcast-shafts and on main haulage-roads. Here, pure coal-dust is deposited on the roof, sides and floor, and the air is full of floating dust of most extraordinary fineness.

(3) *Methods of Dealing with Dust.*—At present, the principal methods of dealing with the dust are (*a*) by means of water-tubs, which water the floor and sometimes spray the water over the roof and sides; (*b*) by means of movable hose-pipes attached to water-pipes laid along the main roads; (*c*) by sprayed water, designed to saturate the atmosphere in the intake-airways and downcast-shaft; and (*d*) by watering the tubs before

they begin their out-bye journey. The water is sometimes sprayed by means of compressed air, and salt-water has been used with good effect.

(4) *Practical Difficulties and Objections.*—In some Welsh mines, the dust is thoroughly laid and rendered harmless, by means of water-pipes laid along the main haulage-roads, and by means of water-tubs. There are mines where miles of pipes are laid and the water is applied with an unsparing hand. In one Yorkshire mine, the air is thoroughly saturated by means of sprays of water and compressed air: this mine is shallow and cool.

The first method could not be adopted in many mines, as such a liberal application of water would cause the floor to lift or heave, the roof and sides to crumble, and the timbering to fall or reel out, and the expense of keeping the roads from collapsing would be prohibitive to its use. Saturation of the air in hot deep mines, even if practicable, has grave objections.

TABLE I.—HYGROMETER-READINGS IN SOUTH YORKSHIRE COAL-MINES.

Place of Measurement.	Temperature.		Remarks.
	Dry Bulb.	Wet Bulb.	
	Deg. Fahr.	Deg. Fahr.	
I. Mine: 2,280 feet deep—			
Surface	58	54	Wet morning.
Intake-airway: near the pit-bottom	$69\frac{3}{8}$	62	
Intake-airway: 3,000 feet inbye	$78\frac{3}{4}$	$68\frac{1}{2}$	
Main return-airway	$85\frac{1}{2}$	$74\frac{3}{4}$	
II. Mine: 1,791 feet deep—			
Surface	51	$45\frac{1}{2}$	Fine bright day.
Intake-airway: near the pit-bottom	61	$54\frac{3}{4}$	155,000 cubic feet of air passing per minute.
Main return-airway	86	$75\frac{1}{2}$	

Table I., recording the readings of a hygrometer in Yorkshire mines, shows that the air in the intake-airways is often remarkably dry, and could only be saturated, or the dust kept damp, by a most liberal and constant application of water.

The watering of roadways in Westphalia has been held largely accountable for the spread of ankylostomiasis, and although recent observations seem to discount this theory, a hot humid atmosphere is likely to affect seriously the health

of those who work in it. The legislature has recognized that such an atmosphere is deleterious to health, and there are provisions in the Factory Acts prohibiting excessive humidity in factories. It would be futile to sacrifice health to safety.

The writer suggests that the following methods, used in conjunction, can be installed without undue cost, and would largely remedy the dust-danger:—(1) The sides and bottoms of the tubs should be made dust-tight, so far as is possible. (2) The full tubs on the main haulage-roads should be watered or sprayed before commencing their out-bye journey. (3) The empty tubs should be watered before they are distributed to the tributary roads. (4) The full tubs should be sprinkled at the coal-face before they start on their out-bye journey. (5) The main roads should be frequently cleaned. (6) The screens should be watered and sprayed so as to prevent the dust from flying about the pit-top; or hoppers should be fixed and the dust collected by suction-fans, on the principle of seed-cleaners. This plan was suggested in the discussion of Mr. Mackey's paper on coal-washing,* and as two members declared their intention of trying it, perhaps they would now give their experiences.

These methods are all designed to cut off the supply of dust, without injuring the roads by excessive watering; but where the roads will stand it, they may be sprinkled as well. It may be added that custom is the only reason for screening and cleaning the coal near the pit-top. This plant could, economically, be placed at a distance.

As long as dusty roads are allowed in mines, the coal-industry is under the dark shadow of a coming great disaster. The looming danger is recognized by all, and the writer submits that this period of peace and immunity is the time to take practical steps to avoid the danger. He believes that a discussion will show that it is reasonably practicable to keep most mines comparatively free from dangerous dust, and that this freedom will conduce to safety, and to health and comfort as well.

* *Trans. Inst. M.E.*, 1904, vol. xxvii., pages 59 and 61.

Mr. J. R. Robinson Wilson (H. M. Inspector of Mines) said that the dust-danger—unlike falls of roof and sides—did not exact the same yearly toll of lives, but when it did arise it was apt to be insatiable, and in some of the modern well-ventilated mines, one was almost appalled to think of what might happen if the dust were thoroughly ignited. He held practically the same views as the writer of the paper. Mr. Pickering went rather farther, however, as he advocated the watering or spraying of the tubs before they left the coal-face; that would be an effectual method, but managers would raise the question of practical difficulties. He thought that the air-currents in the tributary gateways were not usually strong enough to sweep much dust off the tubs; but in the main haulage-roads it was different. Fine dust also came down the shaft from the screens, and was carried far into the mine; and if prevention was better than cure, he suggested that the dust should be caught at each end. The full tubs might be sprayed with water as they left the pass-byes for the main haulage-roads; and it would be a matter for experiment to ascertain exactly how much water was required to last through the journey to the surface. This method had been applied at one Yorkshire colliery, and he believed that it met with great success. The interception of the dust in the downcast-shaft had, he believed, been tried successfully by Mr. R. Harle* at a Durham colliery some years ago. A perforated pipe was placed in the shaft, and the water-spray deposited the dust upon the sump-board. This spray could be placed under the control of the banksman or hanger-on, and turned off when men were riding in the shaft. The question of the injury to guides might be raised, but that difficulty was not insuperable. Iron guides were examined and greased; and wooden conductors, at any rate, did not rust.

Mr. Thomas Stubbs said that the question was one of the greatest importance, especially now that shafts were so deep, and temperatures so high in comparison with what they were in former times. In his experience, there was considerably more dust in proportion when working at a great depth, especially in gas coal-seams, than there was when working at a moderate depth. He agreed with Mr. Pickering that this question should

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 113.

be dealt with on its merits, as his experience in watering roadways was of a varied character, and in some cases it caused upheaval of the bottom-stone.

Mr. R. ROUTLEDGE said that he had been convinced for many years that coal-dust contributed largely to explosions; he first noticed it about 25 years ago, when he saw dust take fire on the wire-gauze of a Davy safety-lamp. He was one of the first explorers who descended the shaft after the Micklefield colliery explosion, and was then more convinced than ever of the dust-danger, and in the district where the explosion occurred they could write in the dust. He was surprised that some of H. M. inspectors of mines, who agitated very much about coal-dust, were actually in favour of the use of electric motors at the coal-face. He would never put an electric motor at the coal-face, particularly in a pit where there was any liability of an outburst of gas. He was afraid that the use of motors at the face would be responsible for a tremendous explosion, sooner or later.

Mr. W. H. CHAMBERS said that the dust-danger had been in his mind ever since he had anything to do with mines. He had taken into consideration the question of preventing dust from going down the shaft from the pit-hill, and though he had not effected much, yet a great deal had been done. He had made many enquiries, but up to the present he had not realized his ideal of what ought to be, and of what could be done in that direction. The dust in the pit was a very difficult question to tackle; he had made many experiments in the way of watering, spraying and salting the dust. A spray fixed in the Denaby pit saturated the floor and sides for a distance of 600 feet, but beyond that distance the pit was as dry as ever. The air did not carry the moisture very far, and the wetting of the floor and sides caused considerable falls. They now wetted the floor, and that work was carefully done by hose-pipes from taps fixed on the main water-pipes. That system was carried out all over their pits, and they found it to be most effectual, as a man could exercise discretion regarding the amount of water required, better than a machine. With regard to the watering of the corves at the face, the members would recognize the difficulty mentioned by Mr. Wilson. Another matter was the arrangement with the men about the tare of the tubs; it might be awkward, but a reason-

able amount of expense should not be set against enhanced safety, though, at the same time, it was a matter for careful consideration before they could put the system into operation. As pits became deeper, there was more grinding of the coal than in shallow mines, and this question undoubtedly would have to be considered. There were many good suggestions set forth by Mr. Pickering in his paper, for which they were all much indebted to him; and he had no doubt that they would be used in trying to arrive at some method of dealing with this common enemy.

Mr. W. Walker (H. M. Inspector of Mines) said that, at one colliery belonging to Messrs. Bell Brothers, Limited, near Durham, the watering of tubs was done by mechanical means, from a cistern in the roof worked automatically by the tub-wheels passing over a lever in the rails, and by which a valve was opened. It was found, where the tubs were tight and well made, that about a quart of water per tub was sufficient to allay the dust in the tub, until it got out of the pit, about 1½ miles distant. The effect of this arrangement was very marked. Previously, the engine-plane was full of fine dust, but when this dust was removed and the tubs were watered as described, its condition became quite different,* and continued to be so. At another large colliery, about 1,800 feet deep, considerable trouble was experienced with the dust from the screens. Open gas lights were used at the pit-bottom, and they had to be removed on account of inflammations of the coal-dust, which went down the shaft. In that case, steam-jets were applied on the jigging-screens with good effect, and the quantity of dust going down the shaft was very considerably reduced. At other mines with which he was acquainted, salt was used in the main haulage and travelling-roads, where water could not be used with satisfactory results, on account of its injurious effects on the roof and sides. He agreed with Mr. Chambers that wherever it could be adopted, there could be no better method of watering than by stand-pipes placed at intervals and combined with the removal of the dust-accumulations from the roads, it was much better than water-spraying or any other means.

Mr. I. Hodges thought that Mr. Pickering had given one of the principal solutions of the difficulty in his first suggestion,

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 113.

namely, "that the sides and bottoms of the tubs should be made dust-tight." During the past two years, his firm had renewed the whole of their rolling stock at one pit with perfectly tight corves, having pressed-steel bottoms, and grooved side and end boards with iron tongues. He did not think that as much dust was blown from the top of a tub as was lost from a tub having defective sides. He had found with steel-bottomed tubs the disadvantage of a heavier tare, but they were able to carry a bigger load, and they were sure, when that load reached the pit-bottom, that the roads had been kept clean. As mines got farther inbye and were perfectly dry, it was not easy to get water to the end of the haulage-roads. It certainly entailed heavy expenditure, as pure water must be used to prevent "furring" of the pipes. With regard to dust from the screens, he had no doubt that all new screens would be placed as far from the pit-top as possible. He had found that by keeping the shaft-buntons wet, a large amount of dust was caught.

Mr. J. Gerrard (H. M. Inspector of Mines) said that there could be no discordant note as to the obvious danger of coal-dust. They had tried to prevent colliery explosions by improved ventilation; and possibly, in no branch of mining had greater advances been made than in this; but increased ventilation influenced the amount of coal-dust. Improvements had been made in the lighting of mines, and much had been done to diminish the danger from the use of explosives. In these three branches of mining, which, in times past, were associated with explosions, Yorkshire had taken the foremost position. But, so far as his knowledge of the county went, they were not in line with others in dealing with coal-dust. The great danger was proved at Micklefield collieries; it had also been proved at Altofts colliery; and Mr. Garforth had made it known far and wide, how coal-dust contributed to the loss of life at Altofts colliery. In South Wales, there was a long list of collieries where coal-dust was being tackled. At more than 40 collieries, pipes were laid in the roadways; at several, the total length established amounted to more than 60,000 feet; and much had also been done in Durham and Northumberland. So far as his experience went, he did not think that they could depend upon fixed water-sprays. Spraying, undoubtedly, was the easier

way, but it was not the most effectual, and he thought that the definite conclusion had been arrived at that stand-pipes with attached hose-pipes were the best. He did not think that the remedy was altogether connected with the tubs; they wanted something more, for if they had absolutely dust-tight tubs, a large amount of dust would be taken from the top, more especially in the case of high-speed haulage. Dust would have to be tackled from all points; and, apart from the question of danger, much more work was possible on a road free from dust, than on a thickly-coated dusty road.

Mr. W. E. Garforth though that it was very much better to deal with the cause than with the effect, and if they could prevent dust from going down the pit, it was better than having the dust accumulating on the bars and interstices of the roof, to be dealt with by water-sprays. These were good for the dust, but bad for the roads. As they knew, he (Mr. Garforth) gave evidence before the Royal Commission on Accidents in Mines in 1891. It was a very exhaustive enquiry, and the result was that especial attention was directed to the danger of coal-dust. After referring to improvements in ventilating, lighting, blasting, etc., he (Mr. Garforth) placed value on dust-tight tubs, adding that if the directions mentioned by Mr. Pickering in his paper, what had been said by previous speakers, and a careful perusal of the Report of the Royal Commission on Accidents in Mines, were combined, together with the exercise of a little common sense, a great deal could be done to prevent accidents from coal-dust. The quantity of dust that was accumulated in some mines, 2,000 or 2,500 feet deep, was not as great as it was in some mines at a depth of 1,000 feet. In some deep mines, like the Roger mine in Lancashire, the coal was strong, and very much less liable to make dust than the Silkstone seam in Yorkshire; consequently, there was not the same danger. In reference to Mr. Routledge's remark regarding the use of electric motors at the coal-face, he (Mr. Garforth) directed attention to the experiments that had been made on the subject of electricity in mines. He would find that in a colliery, where there was coal-dust, with a hermetically sealed motor, no danger need be apprehended.

Mr. A. B. Hewitt (Stanton colliery) wrote that Mr. William Galloway had stated that 1 pound of dust was inflammable, not

explosive, in 160 cubic feet of air, also, that an explosive mixture was formed in the presence of 1 per cent. of fire-damp. He would like to know whether, in the opinion of Mr. Pickering, an ordinary mine-official would be likely to discover 1 per cent. of gas. And, if he failed to discover this amount with his safety-lamp, and an explosion occurred, would it be put down to coal-dust? If the mine had been reported free from gas before an explosion, most probably the dust-theory would be introduced, whereas the origin of the explosion had been 1 per cent. of gas. He (Mr. Hewitt) would also like to know whether Mr. Pickering considered that all dust was dangerous. If not, where would the distinction be made? The removal of dust would tend to increase the danger, unless it had been thoroughly saturated. At some mines, as a preventive against the spread of an explosion, lengths of brick arching had been built at variable distances apart, kept clear from dust, and watered with salt-water, with the intention of preventing the explosion from passing over the wet part, provided that it was of sufficient length.

Mr. W. H. Pickering, replying to the discussion, wrote that the object of his paper was not to reiterate or review previous exhaustive papers and books on this subject, but to ask whether they, as practical men, were not bound to take some action to remove or at least to scotch a very grave and recognized danger. Apart from dust being a serious element in the spread of explosions, it was as inflammable as tinder, and if possible, should not be allowed to accumulate in mines. A fire in the main intake-airway of a modern colliery might be as disastrous as an explosion of fire-damp. He (Mr. Pickering) believed that such a fire would travel inbye in some dusty roads, at such a rate that it would be impossible to get the men out before they were overcome. At a recent fire on the surface at a Yorkshire colliery, an eye-witness stated that the flames ran along the dusty pit-frame as though the dust had been gunpowder.

The cost of watering the full tubs, before they left the face, would not be serious. A small watering-can with a fine rose might be provided. It would only be necessary to sprinkle the tubs with a quart of water or even less. Watered dust caked, and was not easily swept off even when dried by evaporation. The suggestion was only thrown out, however, as a possible

auxiliary to other watering. The shaft-spray would be effective, but the danger of damaging the winding ropes as well as the guides would have to be considered. This was not a very serious danger, if the ropes and guides were properly and regularly greased.

It was gratifying to find Mr. Routledge, one of the pioneers of the coal-dust theory, taking part in the discussion. Compressed air and water-sprays were now used at Micklefield colliery, and the dust was most effectually damped. Mr. Routledge was right in supposing that electricity had introduced a new and serious element of danger, but his remedy was perhaps, if anything, too heroic.

The temperatures taken by dry-bulb and wet-bulb thermometers were given, in order to show the practical difficulty of damping the roads of deep hot mines, owing to the dryness of the air passing. The experience of the effect of watering on many roads, causing the bottom to lift, etc., was a common one, and it was probable that few roads of the deep mines to be opened in Yorkshire would stand heavy watering. This was another argument in favour of cutting off the supply of dust.

The 10 or 12 degrees between the readings of the dry-bulb and wet-bulb thermometers at Denaby colliery proved that the water soon evaporated. He (Mr. Pickering) had seen at Cadeby colliery, how a few buckets of water thrown on the side of a road would cause a fall. Mr. W. H. Chambers thought that watering the tubs at the face would alter the tare; but the alteration, if any, would not be a serious one. Watering the tubs on the engine-plane was, however, more important.

The cases shewing the efficacy of watering the tubs mentioned by Mr. W. Walker were most valuable. Could that gentleman supply further particulars of the firing of dust by gas-flames at the pit-bottom? Did the dust flash at the gas-jets, and how far did the flame extend?

It was true that many shallow mines were as dusty as deeper ones, but on account of the heat and the dryness of the air in the deeper mines, it was more difficult to deal with the dust in these pits. Modern deep collieries were designed to raise 3,000 tons up one shaft, and if the seam happened to be naturally a dusty one, the danger would be great. At such collieries the screens should not be placed near the pit-top. The dustiness of a seam depended upon the structure as well as on the hardness of

the coal. Dangerous dust often consisted of the spores and seeds of the mosses, which flourished when the seams were formed.

Mr. Garforth in replying to Mr. Routledge, upon the question of electricity, pointed out that contrivances had been devised to reduce the danger from sparks from electric motors underground. In all probability, these would, eventually, be made effective, and other precautions would be taken at electrical installations. But the fact remained that electricity had introduced a new and serious danger into mines. Accidents would happen with the best regulated machines, and cables would be broken through careless handling, etc. A slight explosion of gas was recorded at a Yorkshire colliery in 1903, due to the cable of an electric coal-cutting machine being cut by a fall of stone.

It was difficult to say when an explosion begins and an inflammation ends: much depends on the speed of ignition. Neither an ordinary mine-official, nor anyone else, could discover 1 per cent. of fire-damp with a safety-lamp. Such a percentage would not form an explosive mixture in dust-free air; but, in conjunction with dust, it would form an explosive mixture. It was immaterial whether the explosion of such a mixture was called an explosion of dust or of fire-damp. It might properly be described as an explosion of dust and fire-damp, though dust would be the predominant partner, for it would be inflammable by itself whilst the 1 per cent. of fire-damp would be harmless in dust-free air.

He (Mr. Pickering) did not consider that all dust was dangerous. Fire-clay and stone-dust would not explode, but these dusts were injurious to health when breathed with the air. The removal of dust need not increase the danger of explosion, if it were done at the right time and proper precautions were taken. Wet zones had been formed in some mines with the object of preventing the spread of an explosion and ensuring a limitation of the explosion. Such measures did not, however, go to the root of the evil, and it was better, if possible, to cut off the supply of dust altogether.

The President (Mr. T. W. H. Mitchell) moved a vote of thanks to Mr. Pickering for his interesting paper.

Mr. M. H. Habershon seconded the resolution, which was carried.

DISCUSSION OF MR. M. GEORGI'S "NOTES AND CONSIDERATIONS ON SYSTEMS HAVING WORK OF AN INTERMITTENT AND IRREGULAR CHARACTER TO PERFORM: METHODS OF LOAD-COMPENSATION."*

Prof. G. R. Thompson (Leeds) said that Mr. Georgi's paper assisted the members in forming opinions on a very important subject, namely, the application of electricity to winding, and by showing what could be done with the best steam-engine working under the best conditions would give users of steam winding-engines reason to ask whether their arrangements were the most suitable and economical. By suggesting such questions, it would of necessity tend to the improvement of steam winding-plants.

In connection with equation (1)† and Fig. 1 (Plate IV.), he would like to ask a question, which was rather of academic than of practical interest. It would be noticed that, for each value of p, there were two values of the velocity, V, of winding the given load, p: one decreasing as p increased and the other increasing as p increased. The mathematical problem solved was really more general than the winding problem propounded, and he would like to know the construction that the author would place on the second value, and also the interpretation that he would give to the negative values of p and V. Returning to equation (1), if the formula were applied to a winding-engine, it would be found that while the acceleration chosen was reasonably high, and possibly not exceeded by many winding-engines, the retardation in the latter would vary much according to the weight of the usually unbalanced rope relative to the coal wound. It would generally be found that, as the speed increased towards the middle of the wind, the average effective pressure in the cylinder of the winding-engine decreased, profoundly modifying in practice the peak-load shown on the diagrams. The equation (1) clearly indicated the advantage of heavy lifts and slow speeds, if the maximum variation in the demand for power only were considered; but, unless the gearing of the winding mechanism were modified, this would involve a large engine (one capable of giving a big turning moment) and

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 89.

† *Ibid.*, pages 89 and 112.

one developing comparatively little power for its size: a state of things which would lead to large radiation and condensation-losses in steam-engine practice, as well as to heavy machinery.

He (Prof. Thompson) considered that the methods proposed were adequate to throw a steady or practically steady load on the steam-engine, but he was doubtful whether this did not in some cases involve as many disadvantages as advantages; and he would ask whether the need for uniform power-demand from the central station could not be removed by modification in winding-plants, if electrical, and whether the steam-plant could not be in like manner improved. At the last meeting, it would be remembered, he pointed out that it was recognized that the load could be largely equalized by adopting excessive counter-balance. Since then a paper had been read at the Birmingham meeting by Mr. E. H. Roberton dealing with this phase of the question;* he (Prof. Thompson) need, therefore, only give as an illustrative example, a particular case of a steam winding-engine.

The engine winds a load of 5 tons from a depth of 1,260 feet and requires an effective steam-pressure on the pistons of 20·8 pounds per square inch to balance the load of coal. It requires an effective pressure of 14 pounds per square inch to balance the hanging rope, but this pressure decreases 1¼ pounds per square inch for each revolution. Allowing 10 pounds per square inch as the effective pressure required to overcome friction, an average effective pressure of 45 pounds per square inch is required to just start the wind. At the end of the last revolution, the effective pressure available for retardation is 17¾ pounds per square inch, since the pressure has been decreasing 1¼ pounds per revolution.

The moving masses estimated at their equivalent peripheral values are: Rope, cages, tubs, coal, etc., 63,800 pounds; two pulleys, equivalent, 12,000 pounds; and drum, equivalent, 43,000 pounds; a rough total of 120,000 pounds. By timing the wind, the acceleration found was $g/12$ or 2·7 feet per second per second, for this an average effective pressure of 17·8 pounds per square inch on the pistons is needed. The retardation is about the same as the acceleration. If, however, a tail rope had been used of equal weight to the winding rope the effective pressure to just start the

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 557.

load would have been 31 pounds per square inch with the same at the end for retarding. Reckoning the same initial pressure as before for winding, the pressure available for acceleration is 32 pounds per square inch: the acceleration being therefore 0·15 g, and the retardation about the same. Any excess of counterbalance added, will increase both the acceleration and the retardation, and consequently will enable the engine to wind quicker or heavier loads. Thus, if a specially flexible flat tail rope of double the weight of the winding rope be used, the effective load and friction at the start should be made equal to 17¾ pounds per square inch effective steam-pressure on the piston and at the end to 44¼ pounds per square inch; or the acceleration would then be 0·29, and the retardation about the same. The acceleration could be reduced if desired, and the engine worked on expansion from the beginning of the wind, the retardation remaining unaltered and being sufficient to bring the machine to rest in 7 seconds from a maximum velocity of 45 feet per second, or in a little less than three revolutions.

By such means as this, a steam-engine could be made to work under its best cycle for fully six-sevenths of the wind. In this connection, he (Prof. Thompson) desired to point out another way of decreasing the steam-consumption in a winding-engine by equalizing the load throughout the shift, namely, by shortening the time of banking. Mr. Georgi allowed 45 seconds for changing 4 tons 10 cwts., whereas by adopting such banking arrangements as are in use at Cadeby colliery, the time can be reduced to 5 seconds, thus rendering fully 90 per cent. of the time available for active winding. Keeping the engine under steam for a longer portion of the winding time, would enable one to reduce its size and the size of the connecting steam-pipes, and to reduce the consumption of steam thereby. Such considerations apply equally to electric winding-engines and render the equalization of the load an easier problem, but one attended with less advantage.

He (Prof. Thompson), in considering the acceleration-losses,* had some difficulty in accepting the loss as infinitely great when j is zero. The difficulty arose in taking j to the limit, in which case, when j equals zero, the velocity, v, could only be acquired

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 98.

in infinite time and through an infinite space, whereas the wind is limited to the depth of the shaft. The diagram of work (Fig. 7, Plate IV.)* on which the loss in starting through a rheostat was based, was, however, open to question. In starting, an overload current is allowed to flow, this being kept from exceeding a maximum by means of a resistance, which is completely cut out when the counter electromotive force generated by the motor is capable of effecting this purpose. The machine is still overloaded, and its speed increases with increasing counter electromotive force and decreasing current. The loss of work must, therefore, not be reckoned on the final velocity, but on the smaller one at which the machine runs when overloaded. A diagram like Fig. 7 (Plate IV.) with the horsepower falling from 1,500 to 750, could only be secured by switching in resistance suddenly after the acceleration-period is passed. This change of diagram will of course vitiate the conclusions subsequently deduced regarding the relative advantages of starting resistance or voltage-converters.

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* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 112.

SYSTEMATIC TIMBERING AT EMLEY MOOR COLLIERIES.

By H. BADDILEY.

Systematic timbering is a subject that every colliery manager and every colliery official should consider very seriously, and the writer feels that colliery managers should use every endeavour to reduce the number of accidents from falls of roof and side, until they have established at their collieries the system of timbering that would best suit each particular seam or district under their charge. It is the duty of colliery managers to educate their officials, and they again, with the help of the former, should endeavour to educate the miners. After three years' experience the writer feels sure that this can be done. He has been hammering away at his men for the past three years; he is highly satisfied with the progress that has been made, and great credit is due to the miners for the way in which they have fallen in with the improved system of timbering.

Wheatley Lime Coal-seam.—For the purpose of explaining more fully the system of timbering in the Wheatley Lime coal-seam, under the writer's charge, sketches have been prepared (Plate IV.) shewing the systems adopted where coal-cutting machines are used; and where the coal is got by hand-labour.

Machine-faces.—In the machine-faces (Fig. 1, Plate IV.), two rows of props, *A* and *B*, only are left along the face, after the coal has been filled away (Fig. 2). A third row, *C*, is set behind the machine as soon as the coal has been under-cut (Fig. 3), and as the coal is filled away the filler sets another row, *D*, about 2 feet from the last one, *C* (Fig. 4). The two back rows, *A* and *B*, are then drawn out, leaving only the two rows, *C* and *D*, next to the face, about 2 feet apart. The distance from prop tc prop along the face varies from 2 to 2½ feet. The rows of props are set perfectly straight. As an instance, not long ago, measurements were taken in a face 675 feet long: (1) the distance, from

the coal-face to the first row of props, varied from 3½ to 4 feet, the number of props set being 280; (2) from the first to the second row, the distance varied from 2 to 2½ feet, the number of props set in this row being 136; and (3) in no case, along the face, was a prop found more than 6 inches out of a straight line. It was possible to set a mining dial at one end of this face, and take a bearing to the other end, 675 feet distant. This face had travelled over 1,500 feet by machine-work, and was advancing at the rate of 16½ feet per week.

Previous to introducing this systematic method of timbering, the props were set in a rather irregular manner; the roof, being composed of strong bind, came on in very heavy weights, breaking the straggling props one by one, and finally came in along the face. Wood chocks were tried with better results, but as they proved rather expensive, the system of setting two rows of props close together in a straight line was tried. With double the number of props in the row, the roof now breaks off in a straight line, close behind the back row of props, and there is not half the trouble with the face falling in, in fact it is almost a thing of the past, and very few chocks are set now.

Hand-worked Face.—The system (Fig. 5, Plate IV.) in the hand-worked places is somewhat similar to that in the machine-faces, except that a row of props, *C*, 5 feet apart, is set along the face, close to the coal, before the coal is holed (Fig. 6) and two intermediate props are set between them after the holing is done and before the sprags, *D*, are drawn (Fig. 7).

New Hards or Silkstone Coal-seam.—The Silkstone coal-seam, 80 feet above the Wheatley Lime coal-seam, is worked mostly by shallow-cut machines, and the system of timbering is not quite the same as in the seam below. The roof being composed of a softer bind is broken off much more easily; and the seam, being thin, varying from 1½ to 2 feet in thickness, is packed solid in the goaf, with the holing and ripping dirt. In this case, only one row of props is left to support the roof, after the coal has been filled away, but another row is set, as the holing is done. The props are set in a straight line, the rows are placed 3½ feet apart, and the distance from prop to prop in any row does not exceed 3 feet.

Blocking Coal-seam.—This seam, 120 feet below the Wheatley Lime coal-seam is also a thin seam (coal, 20 inches and bottom-dirt, 6 to 8 inches) with a thick roof, composed of alternating layers of strong bind and sandstone. It is worked by coal-cutting machines. The system of timbering is similar to that adopted in the New Hards coal-seam. An ample supply of lids is sent daily to the working-faces: no prop being set without a lid. The lids are 12 to 18 inches long, 3 to 6 inches wide, and 2 inches thick. The lids save the props, and allow them to be more easily withdrawn.

Barnsley Soft or Warren House Coal-seam.—The writer has charge of a small colliery working this seam, and until about 2½ years ago it was worked on the bord-and-pillar method, because he was given to understand that the roof was too tender for the longwall method. However, he adopted the longwall method, although the workmen said that the face would be closed in less than one month; and when the first big weight came on, the men came out, remarking, that the face was finished, and that everything would be buried. However, very little damage was done, and the same face is still working.

This seam is worked by hand-labour. The section varies from 4½ to 5 feet of dirt and coal. The roof is composed of rather soft grey bind. Two rows of props are set along the face, 3 feet apart, and the distance from prop to prop is 2½ feet. Another or third row is set close to the coal, and the distance from prop to prop is about 5 feet. This row is set before the men commence to hole the coal; and, when the holing is done, intermediate props are set. Hard wood lids are used in this seam, 18 to 24 inches long, 6 inches wide and 1½ inches thick, and they obtain a good hold of the rather soft roof. The seam works very well on the longwall system, and the roof gives but little trouble.

Conclusion.—The writer feels sure, if the workmen are taught to set timber in a systematic way, and a strict supervision is kept over them by the officials, that the number of accidents from falls of roof can be most materially reduced.

Mr. A. J. Tonge's paper on "A Colliery-plant: its Economy and Waste," was read as follows:—

A COLLIERY-PLANT: ITS ECONOMY AND WASTE.

By A. J. TONGE.

Introduction.—The question of waste of coal has, of late, occupied a large share of the attention of mining societies. The Royal Commission on Coal-supplies has had the matter under consideration for two-and-a-half years, and its conclusions are awaited with interest. It is, however, with one branch only of the economy or waste at collieries that the writer proposes to deal in this paper, namely, that taking place in the boiler fire-holes, either from the efficiency or from the want of efficiency of the boiler, or of the engines which the boiler feeds.

It is certainly late in the day to point out that the calculation of the coal burnt in the fire-hole, as a percentage upon the amount of coal raised, affords no reliable guide to the efficiency of a colliery-plant. It signifies nothing to say that the coal-consumption is under 5 per cent. of the coal raised, for there is no attempt in this statement to estimate the actual work done, which is essential. And again, it is late in the day to suggest that the true basis of comparison should be that of the quantity of steam used (and not the quantity of coal consumed) to the amount of work done.

In a mine that is already fully developed, where there are full loads on all the surface-engines, it may be possible to effect savings by modernizing the engines and employing proper condensing arrangements, provided that the engines are comparatively close to the boilers; but this can only be thoroughly effective if the loads are fairly full and the engines comparatively modern. In a mine that is new and is developing slowly, it is not possible to have full loads on the engines, and there is greater liability to waste than in the former case.

It may be said that work at collieries is always in a progressive or retrogressive stage. This is fully recognized by those who erect large engines to provide for eventualities, and it is not

sufficiently recognized by those who erect small engines that are likely to break down, at an early date, because of overload. In any case, the economy of the plant suffers. This loss can not be avoided entirely under any system, but the writer is of opinion that it is possible, under certain conditions, to minimize this disadvantage to a large extent.

The figures contained in this paper, which it is hoped may be useful for reference, were obtained at a colliery that is not yet five years old from the commencement of the sinking, where the drawing of coal began only two-and-a-half years ago, and where the output has been systematically kept down, notwithstanding the greater capacity of the plant. The colliery may, therefore, be said to be working under average conditions, that is to say, it is a colliery with a rising output, with proper arrangements for duplicating and extending the body or trunk of the plant, and with a fair reserve for fluctuations and extensions on its limbs.

Winding-engines.—There are two winding-shafts, 1,320 and 936 feet deep respectively. The winding-engines each have two horizontal cylinders and cylindrical drums. There is no balance-rope under the cages, and the cages are brought to a stand without the aid of keps or a scaffold. The engines are supplied with steam from four Lancashire boilers, 30 feet long and 8 feet in diameter, at a maximum pressure of 100 pounds per square inch. Economizers are attached to the boilers. Table I. records the results obtained from extremely careful tests of these engines.

The best results are obtained from the smaller engine; but this is accounted for, to a certain extent, by the greater acceleration and the higher velocity of the moving masses in the larger engine, for, while the height lifted is 40 per cent. greater, the time of winding is only 25 per cent. longer. In the case of the smaller engine, the amount of steam used per horsepower-hour in the coal raised is probably about as low as can be obtained with an ordinary non-condensing winding-engine. Many other interesting figures can worked out from those set forth in Table I., but the writer has thought it best not to include them.

TABLE I.—CONSUMPTION-TESTS OF TWO WINDING-ENGINES.

		No. 3 Pit.	No. 4 Pit.
Winding-engine: Cylinders	... No.	2	2
,, diameter	inches	32	36
Stroke	... feet	6	6
Piston-rod, diameter	.. inches	5	6½
Cylindrical drums, diameter ...	... feet	15	18
Duration of test	hours	7½	7
Average steam-pressure per square inch	pounds	82·8	79·7
Average steam-pressure per square inch, first revolution of engine ...	pounds	65·0	68·5
No. of cut-off revolutions ...	... ..	9	11
Average steam-pressure per square inch during cut-off revolutions ...	pounds	29·0	31·3
No. of revolutions with steam on ...	... ...	11	15
Average steam-pressure per square inch throughout, with steam on ...	pounds	35·25	39·4
Average time, with steam on ...	seconds	15·44	20·0
Piston-speed per minute, with steam on, average value	.. feet	513	540
Indicated horsepower, average value	horsepower	881·5	1,291·1
Horsepower in coal raised, with steam on, average value	... ,,	263·0	311·0
Ratio of indicated horsepower to the coal horsepower, average values ..	... ...	3·35 to 1	4·1 to 1
Total revolutions of drum	... ...	19·125	22·75
Full time of winding	seconds	28·75	34·00
Average piston-speed per minute throughout wind	... feet	478·9	481·7
Average rope-speed per minute throughout wind	... feet	1,953	2,329
Weight of coal raised	... tons	566·55	373·4
Height of winding of coal	... feet	936	1,320
Weight of coal raised per hour ...	... tons	75·54	53·3
Average horsepower in coal raised over whole test	horsepower	80·0	79·6
Total number of windings	... ...	300	213
Weight of coal per winding	... tons	1·888	1·753
Weight of cage, chains, empty tubs, etc.	... ,,	3½	3½
Weight of rope, per yard	pounds	11	11
Steam-consumptions, etc.—			
Steam raised per hour	pounds	7,776	10,019
Steam lost per hour by boiler-leakages	,,	432	432
Steam lost per hour through winding-engine valve, when shut ...	,,	705	1,080
Steam used per hour by winding-engine	,,	6,639	8,507
Steam used per horsepower-hour in coal raised	,,	83	107
Coal used per horsepower-hour in coal raised	,,	17·5	18·4
Steam used by engines per ton raised 1 foot	,,	0·012	0·017
Steam used by engines per ton raised to bank	,,	11·7	22·8
Coal consumed to coal raised	per cent.	0·70	1·23

Generating-plant.—The generating-plant comprizes two Parsons turbo-alternators supplied with steam from two Lancashire boilers, 30 feet long and 8 feet in diameter, at a maximum pressure of 150 pounds per square inch. These boilers are placed alongside the boilers for the winding-engines, and are also provided with economizers. Each alternator has a normal capacity of 300 kilowatts. For the two months ending December 31st, 1904, electrical work to the amount of 238,600 kilowatt-hours was generated, or, an average load of 163 kilowatts. The load varies from a maximum of 247 kilowatts with a steam-consumption of 23 pounds per kilowatt-hour to a minimum of 109 kilowatts with a steam-consumption of 28 pounds per kilowatt-hour. With an average load, the steam-consumption is 25 pounds per kilowatt-hour or 19 pounds per electric horsepower-hour. Table II. records the results of three tests of the Parsons turbo-alternators.

TABLE II.—RESULTS OF TESTS OF TWO TURBO-ALTERNATORS OF 300 KILOWATTS. THE AVERAGE READINGS ARE RECORDED.

No. of Test		(1)	(2	(3)
No. of machine		851	852	852
Load	kilowatts	314·4	311·2	106·5
Duration of test	'minutes	150	202	122
Kilowatt-hours, No. 1 meter		383	512	95
Kilowatt-hours, No. 2 meter		406	545	120
Total kilowatt-hours		789	1,057	215
Power-factor		1	1	0·98
Volts		462	465	462
Ampères		391·1	383·3	137·5
Volt-ampères		782	1,039	218·9
Main field	ampères	9·6	11·3	9·8
Revolutions of turbine		3,010	3,040	3,060
Steam-pressures per square inch	pounds	144	147	149
Vacuum at condenser	inches	26·2	26·7	27·65
Height of barometer	,,	30·05	30·0	30·0
Steam used per hour	pounds	6,996	6,837	2,991
Steam used per kilowatt-hour	,,	22·3	22·0	28·1
Steam used per electric horsepower-hour	,,	16·6	16·4	21·0
Load on plant		Full	Full	One-third

The writer records in Table III. how much of the useful electricity leaving the switch-board at the generator is lost, before becoming the mechanical brake-horsepower of the motor at the point where the power is applied to useful work. This corre-

sponds with the brake-horsepower of the ordinary steam-engine, and the comparison between the steam used per brake-horsepower of the motor and that used per brake-horsepower of the ordinary steam-engine, recorded in Table V., shews the economy or loss due to the use of motors or steam-engines. The writer has not taken into account, in this paper, the extra convenience afforded by the use of electric power for many purposes and for positions where the use of steam is debarred by the distances; and allowance has only been made for comparatively short lengths of pipes from the boilers to the engines in the case of steam-driving. In addition to the motor-load of 164 horsepower shewn in Table III., an average continuous load of 53 electric horsepower is supplied from the same generator for lighting purposes, making a continuous output from the generator of 217 electric horsepower.

TABLE III.—CABLE-LOSSES AND MOTOR-EFFICIENCIES.

Work of Motors.	Haulage.	Screening-plant.	Pumps.	Ventilating-fans.	Other Fans.	Coal-cutters.	Small Motors.	Saw-mill.	Briquette-plant.	Totals and Averages.
Number of motors ...	3	2	4	3	4	3	4	1	2	26
Normal rating, brake-horsepower ...	68	90	87	120	20	40	19	45	90	579
Average distance from generator, feet	1,230	216	402	1,371	282	3,234	288	255	1,110	924
Average working load, electric horsepower	30	48	71	100	16	49	13	26	83	432
Cable-efficiency, the electric horsepower being unity ...	0·98	0·99	0·98	0·96	0·99	0·95	0·99	0·99	0·96	0·97
Motor-efficiency, the electric horsepower being unity ...	0·68	0·76	0·86	0·86	0·80	0·86	0·80	0·85	0·88	0·84
Combined efficiency, the electric horsepower being unity	0·66	0·75	0·84	0·83	0·79	0·82	0·79	0·84	0·84	0·82
Average load in brake-horsepower while working ...	20	36	60	82	13	40	10	22	70	353
Average continuous load on generator, electric horsepower	...	...	...	...	...	...	...	...	...	164
Maximum load on the generator, electric horsepower ...	...	...	...	...	...	...	...	...	...	329
Minimum load on the generator, electric horsepower ...	...	...	...	...	...	...	..	...	...	145

TABLE IV.—SHORT DESCRIPTION OF THE WORK PERFORMED BY THE MOTORS.

Haulage.—There are three separate haulage-plants fixed near the pit-bottom: one in each mine. The motors drive the ropes through gearing in two cases, and by belting in the third case. There are two motors of 30 and one of 8 horsepower.

Screening-plant.—There are two screens, driven separately by two motors, each of 45 horsepower. The parts actuated by these motors, include creepers, tipplers, shakers, travelling-belts and lowering-arms. The power absorbed in moving these various parts, when empty, bears a large proportion to that taken when full.

Pumps.—At a mouthing, 450 feet down the shaft, there is a three-throw ram-pump, with a capacity of 10,000 gallons per hour, driven, through gearing, by a motor of 45 horsepower. There is also a centrifugal pump for the turbine-condenser, direct-driven by a motor of 30 horsepower; a centrifugal circulating-pump, for water-softening purposes, direct-driven by a motor of 6 horsepower; and a three-throw boiler feed-pump, belt-driven, by a motor of 6 horsepower.

Ventilating Fans.—The ventilation is effected by means of three Sirocco fans, two being 45 inches in diameter and one 30 inches in diameter, rope-driven from motors. There are two motors of 45 horsepower and one of 30 horsepower. Arrangements have been made for changing the motors for larger ones as the load increases, the object being to keep the load on each motor as near the maximum as possible, and thus maintain the efficiency from the time when the mine is opening out to the time when the mine becomes more extensive.

Other Fans.—There is a forced-draught fan for the high-pressure boilers, two forge-fans and a shop-ventilating fan: all being electrically driven.

Coal-cutters.—A Diamond coal-cutter, with two motors, is undercutting to a depth of 4½ feet and a Hurd bar-type is also undercutting to a depth of 4½ feet.

Small Motors.—Four small motors are used, one for driving the mortar-mill, two in the workshops, and one at the economizers.

Saw-mill.—The saw is driven by a motor of 45 horsepower, allowance having been made for the application of an additional saw in the near future.

Briquette-plant.—This plant is belt-driven from two motors running in parallel, each of 45 horsepower.

Comparison between Existing Conditions and Old Methods.—The writer's object is to set forth a series of figures, plain and reliable rather than elaborate, obtained from actual tests and experience, shewing the beneficial results of the electrical driving of colliery-plant from the standpoint of economy of coal-consumption.

It is difficult to arrive at an average figure upon which to base the steam-consumptions of ordinary small-colliery steam-engines, such as those employed for driving screens, creepers, pumps, small haulages, etc. Tests of two medium-speed non-condensing continuous-running engines, each of 150 indicated horsepower, were made at the colliery, and an average steam-consumption per hour was obtained of 39 pounds per indicated horsepower.

This result is better than the average results obtained from a number of separate tests taken at different works, and collected from various writers:—Mr. J. S. Dixon, in a test covering fifteen engines of 1,202 total indicated horsepower, including a compound-condensing engine for pumping and a compound-condensing engine for electric machinery, two winding-engines, etc., obtained a consumption of steam per hour of 44 pounds per indicated horsepower.* Mr. W. Geipel, at the Bristol wagon-works, with five engines varying from 8 to 100 indicated horsepower, obtained an average steam-consumption per hour of 50 pounds per indicated horsepower.† Sir T. Richardson, in thirty-one engines at his works obtained an average steam-consumption per hour of 51 pounds per indicated horsepower.‡ Mr. H. A. Mavor, in a test of nine small engines from $\frac{1}{16}$ to 16 indicated horsepower (average, 5·2 indicated horsepower), obtained a steam-consumption per hour of 94 pounds per indicated horsepower.§ The average steam-consumption per indicated horsepower-hour, taken over these results, amounts to 56 pounds, and this consumption, on a mechanical efficiency of 85 per cent. amounts to 66 pounds per brake horsepower-hour.

Comparison of the Economy of Motors and Steam-engines.—Table V. has been prepared, in order that a comparison may be made between motor and steam driving. The load taken is that of 164 electric horsepower, representing the average load on the generators shown in Table III. Assuming that the preceding steam-consumptions are a fair estimate of steam-engine consumptions, it is possible to make a comparison of the two systems.

The writer has pointed out that there is great elasticity in the electric plant, and as the full rated power of the existing motors amounts to 579 brake-horsepower or 673 electric horsepower at the generator (the efficiency on this load being higher than on the lower figure as the motors would then be fully loaded), a further load of 34 per cent. can be put upon the motors. The

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 373.

† *The Electrician*, 1901, vol. xlvi., page 898; and *The Electrical Review*, 1901, vol. xlviii., page 341.

‡ *Transactions of the North-east Coast Institution of Engineers and Shipbuilders*, 1894, vol. xi., page 19.

§ *Transactions of the Institution of Engineers and Shipbuilders in Scotland*, 1898, vol. xli., page 319 and Plate XVIII.

lighting at present on the generator amounts to a maximum load of 125 electric horsepower, so that the generators are capable of taking this motor-increase. No further outlay of capital expenditure is, therefore, needed; and, with this higher output, the advantage of motor-driving would be still more pronounced.

TABLE V.—COMPARISON OF MOTOR AND STEAM DRIVING.

Description of Plant	Electric Driving.	Steam Driving.
Efficiency: electric horsepower or indicated horsepower and brake-horsepower	0·82	0·85
Average electric horsepower at generator and calculated indicated horsepower at engine	164	158
Steam consumed per hour per electric horsepower at generator and per indicated horsepower at engine pounds	19	56
Steam consumed per hour per brake-horsepower at motors and per brake-horsepower at engine pounds	23	66
Steam consumed per hour for 164 electric horsepower or for 158 indicated horsepower .. ... pounds	3,116	8,848
Coal consumed per hour for 164 electric horsepower or for 158 indicated horsepower, calculated at the rate of 6·3 pounds of steam per pound of coal pounds	495	1,404
Ratio of coal-consumption, electric to steam driving ...	1	2·8
Amount of coal-consumption per year ... ... tons	1,925	5,492
Cost of coal per year at 5s. 6d. per ton ... ... £	529	1,510
Advantage on motor driving for 164 electric horsepower per annum ... ... £	981	...

Boiler-evaporation.—In order to arrive at a fair estimate of the evaporation and duties ordinarily obtained from boilers at collieries, the writer has included in Table VI., as much for reference as for the purposes of his paper, the results of a number of tests of the evaporation of Lancashire boilers. The average water evaporated per pound of coal over the seven tests was 6·32 pounds. The average selling price of the seven qualities of coal was 5s. 6d. per ton.

Economy of the Plant over One Week.—The results of tests upon two winding-engines recorded in Table I. are only given for 7½ and 7 hours respectively, for an output of 940 tons per day, during which time coal only was raised. There are still 16¾ hours out of the day, during which there is a continuous waste and an occasional use of steam for other purposes, such as raising and lowering men, stores, etc. Tests have been made, when the average conditions were prevailing, with the following results:—The total coal burnt during 16¾ hours was 12,007

TABLE VI.—TESTS OF THE EVAPORATION OF BOILERS.

Boiler Tested	I. a	I. b	II.	III. a	III. b	III. c	IV.
Duration of test ... hours	41	16	12	7½	7	7	8
No. of boilers ...	1	1	1	4	4	4	2
Boilers: Length ... feet	30	30	30	30	30	30	30
Diameter ... ,,	8	8	8	8	8	8	8
Class of coal used ...	Rough slack	Nuts	Nuts	Dust	Slack	Slack	Slack
Steam-pressure per square inch pounds	147	132	85	83	84	80	147
Total quantity of water evaporated ,,	193,240	72,144	51,000	58,370	111,888	70,134	55,925
Total quantity of coal burnt ... ,,	27,776	11,872	7,700	10,528	18,368	11,767	7,924
Evaporation of water per pound of coal ,,	6·95	6·08	6·63	5·50	6·10	5·96	7·05
Evaporation of water per hour ... ,,	4,713	4,509	4,250	7,776	15,984	10,019	7,079
Evaporation of water per boiler per hour ,,	4,713	4,509	4,250	1,944	3,996	2,505	3,540
Temperature of feed-water degrees Fahr.	80	80	52·6	90	72	73	79
Temperature of water on entering economizer degrees Fahr.	—	—	—	90	72	73	79
Temperature of water on entering boilers degrees Fahr.	80	80	52·6	211	205	207	220
Temperature of gases on entering economizer degrees Fahr.	—	—	—	316	427	488	—
Temperature of gases on leaving economizer degrees Fahr.	—	—	—	203	274	261	—
Efficiency of economizers: saving of total heat supplied to steam ... per cent.	—	—	—	10·8	11·6	11·7	12·3
Grate-area per boiler ... ... square feet	36	36	30	36	36	36	25·5
Coal burnt per square foot of grate-area per hour ... pounds	18·8	20·6	21·4	9·7	18·2	11·7	19·6
Coal burnt per hour per boiler ,,	677	742	642	352	656	420	500
Character of load ...	Variable	Constant	Variable	Variable	Variable	Variable	Variable

pounds or 717 pounds per hour; and the steam raised during the same period of 16¾ hours calculated upon the lowest result of 5½ pounds of steam per pound of coal was 66,038 pounds or 3,943 pounds per hour.

The total steam used during a day of 24 hours is as follows:—While coal is not being wound, 66,038 pounds; while coal is being wound: boiler-leakage, 3,132 pounds; valve-leakage, 12,852 pounds; winding, 109,340 pounds; a total of 125,324 pounds: the total steam used throughout the day of 24 hours being 191,362 pounds.

The total coal used throughout the day of 24 hours calculated upon 6·3 pounds of steam per pound of coal was 30,375 pounds or 13·56 tons.

There being 1,157 horsepower-hours developed in raising coal in the day of 24 hours, the steam consumed per horsepower in coal raised was 165 pounds per hour; the coal consumed per horsepower in coal raised was 26·2 pounds per hour; and the coal burnt to the coal raised was 1·44 per cent.

During a week of five working-days, and including two idle days on which steam was wasting, the total steam consumed for 5,785 horsepower-hours in coal raised was 1,088,000 pounds; the average steam used per horsepower-hour in coal raised was 188 pounds; the coal burnt per week was 77 tons; and the coal burnt to the coal raised was 1·64 per cent.

Taking the electric load, on the average, at 164 electric horsepower, the total amount of steam consumed by the generators per week was 523,500 pounds; and the steam lost by boiler and other leakages, 58,800 pounds; making a total of 582,300 pounds. The average weight of steam used per horsepower-hour in the coal raised was 101 pounds; the weight of coal burnt per week was 41·2 tons; and the coal burnt to the coal raised was 0·88 per cent.

The coal burnt for winding and electrical purposes, including wastage, was 2·52 per cent.

Electric Winding.—As the question of electric winding is so much to the front just now, it may be of interest to note the probable effect upon the consumption of coal previously described. From figures supplied to the writer, as the result of tests of electric winding-plant, it was found that the ratio between the

steam consumed per horsepower-hour in the coal raised by steam and by electricity is as 3 to 1. As this ratio applied only to the actual time of coal-winding, and as it was possible that there might be more loss during non-working hours with the electric winding-plant, an average ratio of 2 to 1 for the whole time would be a more reliable assumption.

At this reduced ratio, the saving in coal on the output on which the previous figures are based, amounts to 1,925 tons per annum, or, at 5s. 6d. per ton, a saving of £530 per year.

Conclusion.—The writer feels constrained to state that he has advisedly confined his remarks entirely to the economy or waste as between steam and electric driving upon the basis of fuel and steam-consumption only. The situations in which electric driving is more convenient than steam, or *vice versa,* or the places where some other power may be more convenient than either, have been purposely untouched; as it would not be possible even to attempt this in a paper of moderate length.

The writer records his especial thanks to Mr. W. B. Shaw, electrical engineer, and to Mr. J. Bateson, mechanical engineer, for the valuable help rendered to him, in the collecting together of the figures contained in this paper.

The President (Mr. T. W. H. Mitchell) moved a vote of thanks to Mr. Tonge for his paper.

Mr. J. R. Robinson Wilson seconded the vote of thanks, which was carried.

NORTH STAFFORDSHIRE INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,
HELD AT THE NORTH STAFFORD HOTEL, STOKE-UPON-TRENT,
MAY 8TH, 1905.

MR. E. B. WAIN, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

DISCUSSION OF MR. B. WOODWORTH'S PAPER ON "CONDENSING-PLANT FOR WINDING-ENGINES."*

Mr. B. WOODWORTH said that the main point to be considered in the application of condensing-plant to a winding-engine was whether it would pay; and to secure that, the work and the plant should both be well-proportioned, and a maximum percentage of time-of-running under steam should be obtained. If the winding-engine is small for the work, the terminal pressure and volume of steam used become so large that condensing was costly and not over efficient; while if the engine was abnormally large, the condensing-plant must be prepared to receive the maximum volume of steam, and, in addition, the percentage of time-of-running under steam was also materially reduced.

The CHAIRMAN (Mr. E. B. Wain) thought that Mr. Woodworth had perhaps touched upon one point which more than ordinarily interested colliery engineers, and that was the question of the size of the engine. He thought that many of them had, in times past, made a mistake in erecting too big engines. The old rule was to find out all the possible strains, multiply them by two, and then double them. He thought that was the standing rule for the colliery engineer in days gone by; but the time had

* *Trans. Inst. M.E.*, 1903, vol. xxv., page 156.

come when the sizes of colliery-plant had grown to such an extent that they could not afford to do that, and they must approach much nearer to the actual margin between work and safety. They used to be taught that condensing under all circumstances was economical, but it was now shown that the saving might be obtained at an outlay, which in point of interest on capital would more than counterbalance any saving that might be obtained in fuel.

Mr. B. WOODWORTH said that, in order to be economical in the use of steam, the terminal pressure must be as low as possible in practical work, and the initial pressure must be as high as possible, so as to get the greatest possible work out of the smallest volume of steam.

The special system suggested in his paper was, he considered, very advantageous for working such an engine with its own separate condensing-plant. It would be beneficial to apply the accumulative-injection principle to a large winding-engine even when it was used in combination with a central condensing-plant. In the case of an engine much too large for its work, the cost of condensing would exceed the saving in fuel.

Mr. JOHN GREGORY, assuming an engine supplied with steam at a pressure of 45 pounds per square inch, and another with steam at 100 pounds per square inch, asked which of the two engines would derive the greatest saving from the application of a condensing-plant.

Mr. B. WOODWORTH replied that the power required to perform the work was a factor in the proportion of the terminal pressure. If the steam had a pressure of 45 pounds and the useful effect was 30 pounds, it would take perhaps 0·875 of the stroke to get it, and there would be a terminal pressure of perhaps 25 pounds above the atmosphere in the cylinder. If an initial pressure of 100 pounds was used and it was expanded down, giving an average useful effect of 25 pounds, there would probably be a terminal pressure of about 5 pounds above the atmosphere; but if throttled steam were used to give the same useful effect, there would probably be a terminal pressure of 20 pounds above the atmosphere; consequently, in the former case, a cylinder-full was used at a steam-pressure of 5 pounds

above the atmosphere, and in the latter, a cylinder-full of steam at 20 pounds above the atmosphere, to get exactly the same result.

Mr. J. T. Stobbs suggested that perhaps Mr. Woodworth could give the members some useful facts as to the attainment and maintenance of a vacuum in winding-engines.

Mr. B. Woodworth replied that the maintenance of a vacuum in a winding-engine was a matter of design and proportions to suit the work. The special arrangement described in his paper was intended to overcome this class of intermittent requirements.

Mr. J. Willis read the following paper on "An Electric Indicating Two-wire Signal":—

AN ELECTRIC INDICATING TWO-WIRE SIGNAL.

By J. WILLIS.

It is an easy matter to instal an electric indicating signal, if a separate wire be used for each indicator, with another wire or earth as the return. This arrangement, however, is undesirable in mines, particularly if shaft-cables must be used. Therefore, in order to accomplish this object the writer has been experimenting for some years, and has fitted two sets of his arrangement at the Leycett collieries. The first set, with engine-room indicators, 3 inches in diameter (Fig. 1, Plate V.), was started in February, 1904; the second set (Fig. 3, Plate V.) started in August, 1904, is a lamp-indicator; and both sets have proved very satisfactory.

The idea consists essentially in placing two or more relays in parallel or series-parallel, each shunt or parallel being equal in resistance as shewn in Fig. 1: H, H and H, being three 50 ohm relays; and I and I, being two pairs of 25 ohm relays in series and equal to 50 ohms in resistance, when in parallel with the line. All the shunts being equal in resistance, they each take the same amount of current; and each actuates a relay-tongue, A, against the pressure of graduated springs, E, or weights, so arranged that each relay, J_2 to J_6, in succession, is actuated by a given strength of current: the other relays being inoperative except at that pressure.

The seven relay magnet-coils have a total resistance of 10 ohms, and this should also be the ohmetic value of the relays J_2 to J_6, which are placed between the sections of the line and form a barrier between one section and another. The seven relay magnet-coils operate the seven different tongues, A_1 to A_7, of the relay or local circuit; and each in turn actuates six different indicators or electric lamps, D_1 to D_6, and a signal-bell, U, which rings wherever the signal is given from.

The relay-tongues, A, are supplied with springs, E, of six

different degrees of tension, the bell, U, and D_6 being of the same tension. Normally, the relay-tongues form part of the relay or local circuit, the first tongue having a six-fold strength of spring, the second a five-fold, and so on, to the bell-relay and D_6; these springs all being adjustable. If the strongest current be sent through the magnet-coils (this will be given from the first section, by reason of having comparatively little resistance to pass through) all the relay-tongues will be actuated, but the fact of the first, A_1, being drawn off its own back contact renders the other indicators inoperative: on account of the current-path being severed. If, however, a lesser current be transmitted, it will pass through the relay, J_2, which has a resistance of 10 ohms; the relay-tongue, A_1, will not be actuated owing to lack of current and the strength of the first spring, E_1; however, the second spring, E_2, being weaker, is overcome by this current, draws off its own back contact, and shunts the current through its own indicator. The first tongue, A_1, and the back contact form a path for the current. And, again, as in the case of the first section, the second tongue, A_2, cuts off all others with a weaker spring, due to its leaving its own back contact.

An illustration of what takes place when a signal is given from the third section is shown in Figs. 2 and 3, the X marking the section whence the signal is given, and the dotted lines marking the current-path to the indicator. The first and second tongues, A_1 and A_2, are on their own back contacts, and are forming a path for the current to the third tongue, A_3, which has left its back contact. The fourth, fifth and sixth tongues, A_4, A_5 and A_6, have left their back contacts, but the third tongue, A_3, having broken its back contact, the fourth, fifth and sixth tongues receive no current, and, therefore, are inoperative, hence an indication can be obtained from the third indicator, D_3, only.

Fig. 3 represents a modification of the arrangement shewn in Figs. 1 and 2. In this case a small 4 volts lamp of 1 candlepower is used for each indicator, and they are placed behind a round ground-glass on which the section-numbers are painted: this arrangement gives an excellent indication, when placed below-ground. To light these lamps, a 20 ampère-hour accumulator is

used, lasting about 4 weeks. S_1 to S_6 are low-resistance retaining magnets, which keep the indicator-lamp glowing until the return signal is given.

It is desirable that the line-current should be moderately constant. To allow for loss of voltage, an adjustable circular resistance, G, is inserted in series with the line, so that when the batteries begin to deteriorate, enough resistance may be cut out to compensate for the loss. If required, a small voltmeter, F, and a key, K, may be connected, in circuit, through the adjustable resistance, G, for testing the voltage. The adjustment of the battery-power should not be required more often than once a month, with moderately well-kept lines. The last adjustment of the first set was on November 22nd, 1904.

Batteries for the lines should be of large size, those in use being No. 1 Carporous, with a central zinc and sal-ammoniac solution. With well-insulated lines, the batteries will last about 2 years, after which they can still be used for less important work, as by this time internal resistance will have been set up in the cells.

The voltage required for this system is about 1 volt per section, provided that the sections are not more than 600 feet in length. It is, therefore, possible to use an 8 or 10 holed indicator, using only two wires, and keep well below the maximum pressure laid down by No. 3 Special Rule, section IX.*

For road-ways, No. 8 standard wire-gauge galvanized-iron wire should be used, supported on porcelain insulators, using dry joints with a special method of jointing. The shaft-line, 1,800 feet long, for the first set, is a No. 18 standard gauge copper-wire, rubber-insulated.

On the engineman receiving a signal, say, from the third section, as shewn in Fig. 2, he repeats the signal-number on all the signal-bells beyond, and the same action replaces his indicator ready for another signal. Should any other section signal for him to move, he would not do so until he receives the signal from the section that stopped him: in this case, from the third section.

* *Special Rules for the Installation and Use of Electricity in Mines*, 1905.

The maintenance is a little more costly than an ordinary signal-system, the first set having cost only 3s. 9d. in 14 months, for three adjustments, etc., which took place during this period; and the second set has only been adjusted once in 8 months, at a cost of 1s. 6d. These costs do not include line-repairs, etc. The first cost varies from £1 5s. to £1 10s. per hole of the indicator, above the cost of an ordinary signal-system.

In Fig. 1, one line is shown unbroken throughout: this could be used as a magneto-telephone line, by connecting the condensers, R, R, which do not earth the line to the direct current; but alternating current and speech will pass through to the telephone-instruments.

The system will work equally well on a three-wire electric signal-system. It may be also utilized as a one-wire water-level indicator; as a fire-alarm, either actuated or automatic, using one wire only; and as a party-call telephone-line, using two wires and requiring no batteries at the intermediate stations for signalling. It may also be used as a lift or cage-indicator, and would, in the writer's opinion, be of great service in a shaft with a number of stations, or where winding is done without cage-rests, as the winding-engineman would then be in a position to know the exact position of the cage, irrespective of the stretch of the rope.

The writer claims that, by this arrangement, it is possible to have a one-line or two-line electric signal, which will indicate the section from which the signal has been given. The arrangement is simple and easy to manage, it has a wide range of adjustment, and it is an excellent safety-device for use in mines.

Mr. John Gregory considered that the system was especially suitable for engine-planes and shafts, where there were several hooking-places.

Mr. W. G. Peasegood, speaking from experience of the two sets now in use, said that they had been of great assistance to the officials on long engine-planes. Previous to this arrangement being introduced, when the engineman was "knocked hold," nobody knew whence he had been stopped, and men were

running from one end of the engine-plane to the other in order to find out. With the present arrangement, there were six stations or lengths, and whichever station or length stopped him, the engineman returned the signal-number of that station or length, and rang all the bells on the plane, and he would not move the rope until he received the signal (three) from the place where he had been stopped. Previously, they had known cases where the engineman had been "knocked hold" from two different sections of the engine-plane at the same time; and he had received a signal to "go on" from one of them, while the men at the other place were lifting tubs on to the rails. Should such a case happen under the present system, the engineman would plainly see from two indicators being dropped that two stoppages had been signalled to him. The new system of signals had proved of very great service, and the extra cost had been very slight.

Mr. A. M. Henshaw proposed a vote of thanks to Mr. Willis for his paper, and observed that the mechanical arrangement of the signal seemed complicated; but if it could be so constructed as to be reliable, it would be of very great importance in colliery-work.

The Chairman (Mr. E. B. Wain), in seconding the resolution, said that, for some years past, he had used electric signals exclusively, but it was a three-wire system with the bells in parallel, and the signals had been repeated at each junction or station. That system, in order to get lucid signals, in some cases required as many as ten separate knocks for a signal, and this all took time. The two-wire indicator seemed to be the acme of simplicity, and to be capable of expansion.

Mr. J. T. Stobbs said that the arrangement appeared to depend upon the adjustment of the springs. The polar strength of the relays seemed to be a factor which might vary considerably, and as to whether it would vary so much as to introduce complications in working he could not say.

The vote of thanks was approved.

MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD AT THE ARCADE HALL, BARNSLEY, APRIL 19TH, 1905.

MR. T. W. H. MITCHELL, PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. AUSTEN KING, Chief Mining Superintendent, Dominion Coal Company, Glace Bay, Nova Scotia, Canada.

Mr. PERCY SIDEBOTTOM, Mining Surveyor, Thorncliffe Collieries, Sheffield.

Mr. TARO TOMITA, Mining Engineer, Tokio, Japan.

The PRESIDENT (Mr. T. W. H. Mitchell) read the following "Notes on Capels for Winding-ropes":—

NOTES ON CAPELS FOR WINDING-ROPES.

By T. W. H. MITCHELL.

Owing to his attention having been called to the capeling of ropes, the writer sent several capels to be tested.

(1) The capel of an Elliott locked-coil rope was put on on March 20th, 1904, and taken off on February 4th, 1905, and the following is the result of the test:—Circumference of rope, 4 inches. Total number of wires, 98. With a load of 28·4 tons, the rope pulled rapidly through the capel; with a load of 29·39 tons, the rope broke inside the capel, and finally pulled through.

(2) The second capel of a locked-coil rope was put on on February 4th, 1905, and was taken off and sent to be tested on March 25th, 1905, with the following result:—Circumference of rope, 4 inches. Total number of wires, 98. The rope commenced to pull out of the capel with a load of 14·0 tons; with a load of 46·48 tons, the rope broke inside the capel, and finally pulled through. Seven of the outer layer of wires broke first, then nearly all the remainder of the wires broke together, clear of the fastenings. Several of the wires were broken at different places in the length of the rope.

These results are, to the writer, very disappointing, and it would be interesting to have the opinions and experience of other members in respect of the capeling of locked-coil ropes.

The writer has generally arranged for a workman from the makers to put on the capels, but the rope, the testing of which is first mentioned above, was capeled by colliery-workmen. The length of time that this capel had been in use may have something to do with the bad result; but the workmen contend that it may also have been owing to the split ferrule round which the wires are bent becoming iron-and-iron, when the collars were driven home. The capel would thus not get a proper grip over the whole of the rope, but would only be gripping the split ferrule.

In the second test, the capel had been working for 7 weeks. The portion of the rope that was tested for breaking-strain had sustained the strain of the testing of the capel, so that the reported breaking-strain of the rope must only be considered under these conditions, as the rope was sent out as one for a 90 tons breaking-strain.

In order to compare the locked-coil with the ordinary rope, the writer has had the following tests made:—

(3) This capel had been in use for 11 months. Circumference of rope, 4·05 inches. Total number of wires, 90. The first wire broke with a load of 22·0 tons, and, on the test being continued, several more wires broke. With a load of 32·10 tons, the rope pulled rapidly out of the capel, until, with a load of 42·40 tons, two strands and wires in the remaining strands of the rope broke together, clear of the capel. The wires were broken at different places along the length of the rope.

(4) This capel had been in use for 2 months. Circumference of rope, 3·75 inches. Total number of wires, 90. With a load of 15 tons, the rope had pulled out of the capel 0·11 inch; and the first wire broke with a load of 24·70 tons. The rope pulled rapidly out of the capel with a load of 27·35 tons; and, finally, with a load of 42·08 tons, the rope pulled out of the capel. There was a slight fracture on the capel after the test. After being pulled out of the capel, the rope was tested to destruction. Maximum stress, 46·22 tons. Three strands broke together clear of the fastenings.

The method of capeling is as follows:—

Locked-coil Rope.—Wrap the rope with soft, No. 13 gauge wire, commencing about 7 feet from the end, for about 3½ feet towards the end; then place the two conical wedges on the rope at the end of the wrapping, and make fast with wire. Unwrap the outside wires of the rope, take the twist out and straighten the wires, then turn them back neatly on to the conical wedges as snugly as possible, placing about four pieces of wire round them to hold them in their place. The next layer should be treated in a similar manner, but the wires should be cut shorter to form a taper, and also to allow of all the wires being gripped by the socket. All the remaining layers should be treated in a

similar way. The binding wires should be taken out in each case, except those on the conical wedges. Wrap the rope with one layer of tar-band; heat the capel at the bottom, having some water ready to cool it as you proceed to drive on the hoops, which should be driven securely home.*

Ordinary Wire-rope.—Wrap the rope with a single wire, commencing about 7 feet from the end, for about 3½ feet towards the end, then keep wrapping the wire over and over, until you have formed a knob of the size that you require. Unwrap the strands and straighten them out, turn them back neatly over the knob, as snugly as possible, cutting each layer shorter to form a taper. Wrap the rope with one layer of tar-band; heat the capel at the bottom and drive on the hoops, cooling the capel as you proceed. The hoops should be driven securely home.

Mr. W. Walker (H.M. Inspector of Mines) said that it was rather startling to find, after the comparatively short time during which the rope had been in use, with a load of less than 25 per cent. of the breaking-strain and not very much more than the working load, that the rope had drawn through the capel. The experiment spoke in favour of the periodical re-capeling of all ropes. The form of capel, described by Mr. Mitchell, was, perhaps, not the best that could be adopted for a locked-coil rope. The bending back of the wires round the ferrule was apt to cause damage, and the strain upon the different wires must vary considerably. The best form of capel had a hollow cone, made from a solid forging of Low Moor or other high-class iron. Into the cone, about 9 inches of the ends of the wires of the rope should be carefully and evenly spread out, and then fixed in position by running in good white metal. The end of the rope then became practically a solid cone, which could not be drawn out. On testing a rope with this form of capel, it was found, as a rule, that the rope broke just within the capel at strains varying from 80 per cent. and upwards of the breaking-strain. This capel was used at the Sheffield testing-works in the tests mentioned in this paper. Some rope-makers

* The method of capeling a locked-coil is similar to that described in a "Record of the Failure of a Locked-coil Winding-rope," by Mr. W. Lockett, *Trans. Inst. M.E.*, 1904, vol. xxvii., page 254 and Plate XIV., page 258.

experiments had been made on lines following Mr. Blackett. Mr. F. L. Ward, at the Bradford colliery, Manchester, had completely succeeded in obtaining a capping stronger than the rope. He had seen three tests, in all of which the rope broke clear of the capping. The wires of the rope were opened out, well-cleansed with paraffin, into a warmed solid cap, a mixture of white metal was run to enclose the wires, and before pouring in the hot white metal, the wires were dusted with powdered resin. After completion, the cap was allowed to stand undisturbed until cool, so as to allow of the white metal setting. The best mixture of white metal had proved to be: lead, 60 per cent.; tin, 30 per cent.; antimony, 9 per cent.; and bismuth, 1 per cent. Antimony gave hardness, and bismuth lowered the temperature of fusion. It had been alleged that this method was open to the objection of the heat affecting the temper of the wires, but there was no real foundation for this statement, and many years of actual use had sustained this opinion.

Mr. J. Whittaker, of Messrs. George Hargreaves' Accrington collieries, had obtained very satisfactory results from a similar method. Mr. W. Pickup, of the Rishton collieries, had completely succeeded after numerous experiments, and was convinced that the white-metal cap was the best. Twenty years ago, Mr. Herbert Fletcher introduced, at Ladyshore colliery, Lancashire, a similar capping, which was still used at three pits.

It would be well, if any colliery owner desired to try this method, to make experiments, so as to obtain the necessary confidence by testing the efficiency. This can readily be done at a number of places, one, conveniently situated, being the Sheffield Testing Works, Blonk Street, Sheffield.

Mr. W. P. Abell pointed out that one might get the impression, on reading Mr. Mitchell's paper, that the first principles of engineering had been neglected in the matter of capels; but, as Mr. John Gerrard had pointed out, there was the fact that fewer accidents arise from capels giving way than from other causes. This was easily explained when it was remembered that there was a varying margin of safety in the rope during its life, and a constant margin during the life of the capel: for instance, there was a margin of safety of 10 to 1 for the rope, in order to provide against corrosion and

wear; whereas the capel (as Mr. Mitchell's investigations showed) had only a margin of 5 to 1. In practice, the rope wore out and corroded, but the capel, and the rope in it, did not; so that, although this might be considered bad engineering at the outset, actually in the working-life of the rope there was no weak factor present.

To obtain uniform strength of the capel and the rope, the following engineering principles required attention: The material should not be deteriorated by high tension, temperature or torsion, and the elasticity should not be impaired. It was easy to make a capel much stronger than the remainder of the rope by simply bending back the wires and splicing them again for several feet into the rope: thus practically making the capel contain double the number of wires, but this made a clumsy job and was quite unnecessary. Mr. R. Richardson had asked what was the use of using a rope with a breaking-strain of 100 tons, if the capel could only stand half that strain; but he (Mr. Abell) thought that at the end of the working-life of the average rope the capel would be found the strongest part. The 100 per cent. capel adopted by the Sheffield testing-house appeared to introduce two great elements of uncertainty: for instance the variation in the composition of the alloy and the keeping of the melted alloy at the proper temperature would be well attended to in the hands of leisured experts; but they were liable to be overlooked during the busy time of putting on a new capel at a colliery; and variation in these two requisites would make a capel that would draw and thus become dangerous.

Mr. Isaac Hodges observed that he did not think the deterioration of a winding-rope was nearly so rapid as Mr. W. Price Abell had stated. He had recently had a winding-rope tested at the Leeds University Engineering Laboratory after a life of 4½ years, having lifted 330,000 tons from a depth of 1,200 feet. It was found that the circumference of 4 inches had only been reduced by wear to 3·9 inches, and that the breaking-strain had been reduced from 70 to 60 tons only. The tensile and torsional tests of the rope were practically unaltered: the deterioration being solely due to the lessened area of the wires. It was extremely startling to him as a colliery manager to learn that the capel was only half as strong as the winding-

rope. He was, however, anxious to know whether Mr. T. W. H. Mitchell had discovered any difference in the percentage of safety between ropes of small and ropes of large circumference, because he noticed that the tests detailed by Mr. Mitchell did not extend beyond a rope 4 inches in circumference. He could not conceive a better method of capeling a rope than that given by Mr. John Gerrard, assuming that the metal mentioned would stand wear-and-tear. He (Mr. Hodges) considered that the question was very important, and that the Council should appoint a committee to report upon it. The matter was a serious one for them all, and he was afraid that they had been running more risk than they knowingly would have done.

Mr. W. Hattar wrote that the results of the tests carried out on cap-ends were such as to cause no small amount of disquiet to users of all makes of winding-ropes. Some time ago, he visited a colliery in Staffordshire, where three tests had been made:—Two cappings of locked-coil ropes, and one capping of the style generally adopted for ordinary or Lang lay ropes. The strengths of the cappings of the locked-coil ropes were less than 50 per cent. of the actual breaking-strains of the ropes, as given by the makers, and that of the ordinary rope was 57 per cent. In all three cases, the caps were carefully prepared, under proper supervision, for testing purposes. He (Mr. Hattar) examined the cap-ends and could find no fault in the method of their preparation, especially in the manner of turning the wires, but he certainly thought that the length of capping was extremely short for ropes of the sizes in question, namely, locked-coil, 5½ inches in circumference; and Lang lay, 6½ inches in circumference.

The problem then arose, by what means the cap-ends could be made, if not quite so strong as the rope, as near as is practicable to the strength of the rope. He (Mr. Hattar) had estimated 75 to 85 per cent. as the strength of the capping, in relation to the strength of the whole rope; tests of wires taken from a capping, which had raised over 500,000 tons, in addition to other work incidental to colliery-usage, gave good results. Mr. John Gerrard had described a class of capping, which might be all that was desired so far as strength went, but it occurred to him (Mr. Hattar) that considerable trepidation would be felt by anyone adopting this style for large

winding-ropes, owing to the care required, in manipulation, to make a thoroughly sound cap-end. He (Mr. Hattar) thought that much could be done by way of increasing the percentage of strength in the cap to a nearer proportion of the strength of rope, namely:—(1) By using ropes built of the best material, and thereby ensuring in the first place the maximum amount of strength, consistent with the temper at which the wire was drawn. (2) By adopting the longest length of capping permissible, so as to increase the grip to its greatest extent. (3) By keeping the ropes closely adjusted to the load-length, and thus avoiding slack chain and the resultant shock, due to sudden "snatching of the load"; if there were difficulties in the way of the length of the ropes being so adjusted, then by taking up the slack chain steadily, and other means being taken to recover the time so lost, by increasing the speed-acceleration in the shaft. The stresses put on a rope by the sudden lifting of the load must, in a great number of cases, be nearly as great as that attained when the cap fails, and a rope subjected to these added strains would, when submitted for testing purposes, be in the worst possible condition, owing to material-fatigue. (4) By having the ropes frequently re-capped, and examined at least once a week, in addition to the ordinary daily examination, at the point where the internal wires could be seen.

The appointment of a committee to investigate this question had been suggested; and he (Mr. Hattar) sincerely hoped that it would receive due consideration at the hands of the Council. If the committee were appointed, he would do all that he possibly could to assist the committee in acquiring information on the subject.

Prof. G. R. Thompson said that he would not have advocated an excess-counterbalance of a winding-engine by the tail-rope method, had he not known that a rope could be capped to give as great strength in the cap as in the rope itself. The weakness of the ordinary methods of capping had often been recognized, and some years ago specimens of ropes capped by makers in different manners were tested in the Engineering Department of the University of Leeds. Table I. contained the results, as recorded by Mr. Arnold Lupton.* The efficiencies of these cappings are 49·6, 28·3, 35, and 89 per cent. respectively.

* *Mining*, 1899, page 424.

The method of capping, by filling the socket with white metal, advocated by Mr. John Gerrard and Mr. W. Walker was quite satisfactory: it gave efficiencies exceeding 90 per cent., and the rope broke instead of the capping failing. One would, however, have hardly expected that the strength of the rope was equal to the sum of the strengths of the wires tested; since, in the rope, the wires were not subject to direct tension but to a combined stress. In capping a wire-rope, it was important that each strand and each wire should take its due proportion of the load; and to secure this, in a short test-piece, when testing in the Engineering Laboratory of the University of Leeds, the rope was carefully wrapped, the ends were opened out for a length of about 5 inches and the wires were separately

TABLE I.—TESTS OF CAPPINGS OF ROPES.

Breaking-strain of Rope, as given by Makers.	Maximum Load.	Remarks.
Tons.	Tons.	
30	14·9	Capel with rivets: top rivet of capping sheared, and rope was pulled out of cap.
30	8·5	Capel with collars: capping failed, and rope was pulled out of cap.
30	10·5	Conical socket, with wires bent back: capping failed, and rope was pulled out of cap.
30	26·7	Spliced eye: capping failed, as the splice gave way.

cleaned and dipped in hydrochloric acid: the ends being folded in for about an inch in length.* The white metal, consisting of lead hardened with about 10 per cent. of antimony, was melted and run into the conical cap in which the coned rope-end had been previously placed: the cap having been previously heated to prevent chilling of the metal. The internal dimensions of the cap used in testing were 3½ inches in diameter at the base, tapering to 1⅝ inches at the top in a height of 3½ inches: the cap being 4½ inches in height, and the uppermost inch had parallel sides. In the case of the rope referred to by Mr. I. Hodges, which was tested by Prof. Goodman, he (Mr. Thompson) found that the adhesion between the white metal and the wires had amounted to 10 cwts. per square inch of contact-surface, without the wires drawing, and if friction were

* *Mechanics Applied to Engineering*, by, Mr. John Goodman, page 305, Fig. 285c,

neglected, that the normal pressure between the cone-surface and the white metal would have amounted to 8 tons per square inch, though on allowing for friction, this probably was reduced to 3 tons or less per square inch.

His colleague, Prof. John Goodman, had kindly given him access to the records of tests made by engineering students of the University of Leeds for experimental purposes. These tests, recording all work done both good and bad, might be taken as an average for careless and careful workers and for unskilled workmen. The wires were usually only cleaned with emery-cloth and frequently not hooked over in the cap, while the quantity of antimony in the alloy was estimated and not weighed. Taking the last 50 tests made on ropes breaking with loads varying from 4 to 47 tons, the average efficiency of the ropes (and capping included) was 94·2 per cent., the lowest result being 68·4 per cent. Following this, no rope broke at less than 80 per cent.; one broke at 83·4 per cent.; one at 86 per cent.; one at 87 per cent.; one at 89 per cent.; and one at 89·8 per cent.; the remaining 44 breaking at over 90 per cent. Eight ropes, among these 50, broke with loads over 40 tons, the average efficiency being 96·5 per cent.: the lowest being 86 per cent. In the 25 tests, next preceding the 50 abovementioned, only 3 results were less than 90 per cent., namely, 83 per cent., 84 per cent. and 86·5 per cent. These figures show that the results are higher than those got with ordinary cappings, that they are more uniform and reliable, even when made by unskilled workmen, and that the fear of weakening the rope by annealing the wires by the hot white metal may be regarded as groundless.

In connection with his previous remarks about the pressure between the surface of the white-metal plug and the cone of the capping, he desired to point out that the length of the cap could be kept short, in fact, practically to the length requisite to give sufficient adhesion, according to the diameter and tensile strength of the wires constituting the rope; and the normal pressure from the sides of the cone could be kept low, without unduly increasing its basal diameter, by turning grooves in the interior of the cap.

He would like to direct attention to the great differences of length between the white-metal capping and some of the specimens, which exceeded 3½ feet in length.

Mr. W. Talbot Cheesman wrote that his son, Mr. Herbert Cheesman, had dealt exhaustively with the strength of rope-cappings in a paper* that he had read at the Yorkshire College, some 10 or 12 years ago, but there were one or two features which might be further discussed.

In every case, where a wire-rope required socketing, the utmost care must be taken to preserve the regular tension of the individual wires, and, as may be readily imagined, the more wires there are the greater must be the precautionary measures, particularly so in these days, when practically all ropes of this kind are manufactured from steel of high tensile strength. This steel is not only difficult and stubborn to handle, but it is particularly springy in nature, and consequently most liable to deformation. Therefore, when a rope is being prepared for socketing, it is essential that the workmen should start and serve down to the cut end of the rope, possibly a distance of 10 to 50 feet, depending upon the construction and size of the rope. A wire-rope, made of six strands each containing seven wires of, say, 110 tons quality steel, will not be so liable to disturbance as, say, a wire-rope, 1½ inches in diameter, compound laid, say, containing six strands of nineteen wires. It must be clearly understood that the serving must travel down to the cut-end: there is a specific object in doing this, namely, to force any slack in the strands or wires out at the cut-end.

There are various patterns of sockets or capels, each claiming some respective merit, and in the North of England, the style most commonly used is the long split socket, attached by means of rivets, and taper-rings, driven on to the wedge-shaped section of the socket, and held in position there. He (Mr. Cheesman) particularly desired to point out that, although this was the pattern generally adopted, it appeared to be full of dangerous drawbacks. He had had several cases, which revealed a terrible and treacherous condition, when the rope had been taken out of the sockets. For instance, in one case, a rope suddenly broke close to the socket, and, upon making an examination, it was found that in attaching the socket to the rope five out of the six strands had actually been severed during the process of forcing the punch through the rope to make the holes for the rivets. In another case, where an important ordinary compound-laid best plough-steel winding-rope, 5¾

* *The Various Forms, Uses and Developments of Wire-ropes*, 1893.

inches in diameter, was used, a similar occurrence took place; and, on examination, it was found that three strands, each containing nineteen wires, had been so damaged during the process of socketing that only two or three wires were left intact in each, whilst of the other three strands, two were similarly mutilated, but not to the same extent. From his (Mr. Cheesman's) experience, which had been fairly extensive, he thought he could safely say that many colliery managers would be absolutely shocked and horrified if they were to make a close examination of their winding-ropes in this particular direction; at the same time, whilst not condemning this method of socketing as always bad, he would point out that as a rule sockets were made and drilled for the rivets quite irrespective of the length of the lay of the rope to which they were to be attached; and moreover, as ropemakers' views, as to the most desirable lay at which the respective ropes should be spiralled, varied, it was highly improbable that the rivets would come exactly between the strands, which was the only proper way to attach this style of socket with the minimum amount of depreciation to the rope. In any case, it would be readily recognized that this method necessarily must cause a displacement and general disturbance of the wires, and must materially lessen the actual breaking-strength of the rope.

The taper-socket, made out of solid drawn steel, had the advantage of being attached to the rope, without recourse to any means such as the forcing of rivets and the like between the strands. The usual method employed in making this attachment is to serve the rope in the manner already described, after which the individual strands are prepared in a suitable way by being cut to an exact measurement and carefully marked for bending back and spread in such a manner as to fill into the space due to the taper of the socket; and finally a copper or steel tapered pin is driven firmly down into the centre of the rope, and further spreads and increases the general grip of the rope in the socket. If this system were carried out with great care and precision, he (Mr. Cheesman) considered that it was the best method yet employed for the socketing of wire-ropes. Another system of attaching the rope to the same type of socket, after the strands have been drawn back in the manner before explained, is to fill the interstices with white metal, which forms a solid and homogeneous tapered end to the rope.

There are many other patterns of sockets, all of which are more or less modifications of the foregoing.

In conclusion, he (Mr. Cheesman) would like to lay special emphasis on the absolute necessity of resocketing all winding-ropes at fixed periods, dependent on the conditions under which the rope was working. This resocketing enabled one to ascertain the actual internal condition of the strands and wires, so as to see whether the rope was still safe. In his experience, he had seen ropes which, from their outward appearance, were apparently sound and in good condition; but a closer examination of the internal parts revealed exactly the opposite condition. In one case, a compound laid rope, 1⅝ inches in diameter, looked like a veritable bar of steel, without the sign of a fractured wire: on being opened at the socket-end, the wires, forming the inner strand, which originally measured 0·084 inch in diameter, were less than 0·020 inch in diameter; in some places the wires were practically eaten away; and a similar pitting and corrosion had severely attacked the internal side of the outer wires.

Mr. G. Blake Walker and Mr. L. T. O'Shea's paper on "The Utilization of Surplus-gases from Bye-product Coke-ovens" was read as follows:—

THE UTILIZATION OF SURPLUS-GASES FROM BYE-PRODUCT COKE-OVENS.

By G. BLAKE WALKER and L. T. O'SHEA.

INTRODUCTION.

During the last ten years, the bye-product coke-oven has been steadily winning its way in this country, and at the present time more plants are in course of erection than at any previous period. Should the coal-trade improve, it is probable that many firms which are now considering the question will proceed to the erection of ovens of this type. Hitherto, the bye-products chiefly considered have been sulphate of ammonia and tar products; but in addition to these there is a third residual which has, only within recent years, been recognized as valuable. That residual comprizes the gases which are not required for distilling the coal in the ovens. These gases can be utilized with most valuable results for the generation of power in gas-engines; and, under favourable conditions, are sufficient in quantity to furnish an amount of power equal to supplying the greater part of the colliery-consumption of fuel, assuming that 20 to 25 per cent. of the output is coked. Colliery-consumption costs a large sum, probably from 1½d. to 3d. per ton on all the coal raised, and the amount which can be saved by the utilization of waste-gases is, therefore, very considerable.

The value of the surplus-gases was not much thought of by the earlier inventors of bye-product ovens, and naturally so, because the development of the gas-engine is of comparatively recent date. Latterly, however, attention has been directed to the production of surplus-gas for power-purposes, with the result that ovens have been modified to achieve this object. Economy in the use of gas is sought, by applying the most intense heat as uniformly as possible throughout the length of the oven-walls.

In the earlier types of ovens, the method of burning the gas and air was wasteful and unsatisfactory, and accurate

adjustment was almost impossible. The amount of surplus-gas was, therefore, relatively small. Now, it may be asserted that where a coal contains 28 per cent. of volatile constituents, nearly one half of the gases returning from the scrubbers is available for power-purposes, when the best types of ovens are used.

It is not the writers' object to specify the ovens of any particular type, or to enter into the merits or demerits of any particular design. It is sufficient to indicate the essential principle which should influence the selection of a type of oven, namely, the possibility of accurately regulating the heating of the side-walls with the maximum of efficiency and with the minimum of waste of gas. The writers may, however, remark that the burning time for ordinary coal should be limited, say, to from 25 to 30 hours, as in this case the oven maintains a higher temperature and less heat is lost. The charging of ovens by the compressor occupies the minimum time and exposes the hot walls for the shortest time to the chilling effect of the outer air. The proportion of moisture can be better regulated in this way, and should be kept down to 9 per cent. if possible. Lastly, the more uniform the temperature, the less the wear and tear of the ovens.

With these introductory remarks the writers propose to deal with the subject under the following heads: (1) The composition and properties of the gases from retort coke-ovens; (2) their explosive and heat-values; (3) the cleansing and filtering of power-gas from coke-ovens; and (4) internal combustion motors or gas-engines.

The Composition and Properties of the Gases from Retort Coke-ovens.

From the manner in which the coking process is conducted in retort-ovens, namely, by heating the coal in a closed chamber from which the air is excluded, the gas obtained has a composition similar to that of illuminating or town gas.

It is a complex mixture of several gases, which may be classified as (*a*) heat-producing gases: hydrogen, marsh-gas, and carbon monoxide; (*b*) illuminants: heavy hydrocarbons; and (*c*) diluents: carbon dioxide and nitrogen.

The chief differences in the composition of coke-oven and

town gas, are, firstly, the former is deprived of the benzol in the bye-product recovery-plant, whereas that substance is retained in town gas on account of its high illuminating power. Secondly, the proportion of nitrogen is usually greater in coke-oven gases, owing to the difficulty of keeping the joints in the oven-walls gas-tight; hence air often finds its way from the combustion-flues into the oven, and the nitrogen in the air goes to dilute the gases from the coal. Thirdly, the quantity of carbon dioxide is greater in coke-oven gases than in illuminating gas, because no means are taken to remove it from coke-oven gases, as is the case with illuminating gas.

These points are clearly illustrated by the results of the writers' analyses of gas from a battery of 35 Simon-Carvès ovens at the Wharncliffe Silkstone colliery. The coal used is a mixture of washed slack from the Silkstone, Parkgate and Whinmoor seams, and yields, on an average, 33 per cent. of volatile products by the crucible-test.

The composition of the gas is detailed in Table I., to which are added, for comparison, average analyses of illuminating gas and of the gas obtained by coking Silkstone coal in Otto-Hilgenstock ovens at the Yorkshire Coal and Iron Company's Tingley collieries. The first analysis is representative of a number made

TABLE I.—ANALYSES OF COKE-OVEN AND ILLUMINATING GASES.

Constituent Gases.	Coke-oven Gases.		Illuminating Gas.
	Simon-Carvès Ovens.	Otto-Hilgenstock Ovens.	
Diluents:			
Carbon dioxide, CO_2	2·88	3 to 4	2·0
Oxygen, O	0·91	trace *	0·2
Nitrogen, N	15·68	8 to 12	1·4
Illuminants:			
Benzene, C_6H_6	—	—	0·5
Heavy hydrocarbon, C_nH_m ...	1·6	3 to 4	4·0
Heat-producing gases:			
Carbon monoxide, CO	5·66	6 to 8	8·8
Marsh-gas, CH_4	26·66	31 to 33	33·2
Hydrogen, H	47·07	40 to 50	49·9

by the writers. The quantity of nitrogen is high, and it is due to leakage of air into the ovens, caused by faulty joints in the oven-flues; but not to any special superiority of one type of oven over the other, as may seem by comparing the writers'

results with many of those quoted by Bergassessor Baum,* containing as much as from 34 to 45 per cent. of nitrogen. The tightness of the joints in the oven-walls has a most important bearing on the quality of the gas produced, inasmuch as the nitrogen acts as a diluent, and reduces the heating power of the gases. Consequently, to obtain the greatest economy from the gases, it is essential to reduce the leakage from the oven-flues to the lowest feasible limit. It is hardly possible to obtain the same freedom from nitrogen in coke-oven gases as in gas made in a gas-retort. The latter is small and without joints, whereas the former is of large capacity, and built of comparatively small bricks, with numerous joints, which tend to open by continual expansion and contraction. However, by maintaining a uniform temperature in the flues, and discharging and charging the ovens as regularly and rapidly as possible, the cooling influences are greatly reduced, and, thereby, the dangers arising from excessive contraction are minimized.

The results quoted in Table I. represent the average composition of the gas produced during the whole coking time, but from Dr. Bunte's† experiments on the gases from the coking-plant at the Consolidation colliery in Westphalia, it appears that the composition of the gases varies at different stages of the coking time. If the coking time be divided into five equal periods, it is clearly shewn that during the first and second periods, when the temperature is lowest, the gases, marsh-gas, heavy hydrocarbons, and carbon monoxide, are formed in greatest quantity; but, as the process continues and the temperature rises, the quantity of these gases gradually diminishes whilst that of hydrogen gradually increases, until in the last period as much as 60 per cent. of that gas is present.

Dr. F. Schniewind has obtained similar results, which are recorded in his paper on "The Production of Illuminating Gas from Coke-ovens"‡ to which the writers would refer the members.

If the object is to supply illuminating gas, as in Dr. F. Schniewind's case, it is very important to be able to separate the gas produced in the early stages of coking from that pro-

* *Die Verwerthung des Koksofengases* (The Utilization of Coke-oven Gas), page 10.

† *Stahl und Eisen*, 1899, page 615.

‡ *Trans. Inst. M.E.*, 1901, vol. xxii., page 619.

duced later, on account of its higher illuminating power; but, when the gas is required for power-generation, this would appear to be a doubtful policy, for the illuminants possess a very high calorific power; and in fact Dr. Schniewind shews that the gas produced during the first half of the coking time has a higher calorific power than that produced in the second half.*

The Calorific Power or Heating Value of Coke-oven Gases.

The heating value of coke-oven gas is naturally high, in comparison with that of producer-gas or blast-furnace gases, owing to the large proportion of combustible gases of high calorific power which it contains. Illuminating gas has the highest value of all power-gases, retort coke-oven gas comes next; and its value, expressed in heat-units, more closely approaches that of illuminating gas in proportion to its freedom from nitrogen.

The heating value of a gas depends upon whether the steam produced by the combustion is condensed or not; and, when expressed in heat-units per cubic foot, upon the temperature and pressure at which the volume of the gas is measured. If the steam is condensed, the heating value is higher than when it is uncondensed; and in the gas-engine it is probable that the lower value is obtained.

Determinations of the calorific power of the gases from the Simon-Carvès ovens already referred to were made on three different days, in a Simmance-and-Abady gas-calorimeter. The results calculated in British thermal units per cubic foot, measured at 32° Fahr. and 30 inches of pressure and at 60° Fahr. and 30 inches pressure, are given in Table II.

Table II.—Calorific Power of Gas from the Simon-Carvès Coke-ovens at the Wharncliffe Silkstone Colliery.

Experiments.	British Thermal Units per Cubic Foot at 32° Fahr. and a Pressure of 30 Inches of Mercury.				British Thermal Units per Cubic Foot at 60° Fahr. and a Pressure of 30 Inches of Mercury.			
	1	2	3	Means.	1	2	3	Means.
Steam condensed ...	438	403	402	414	421	386	385	397
Steam uncondensed ...	402	379	373	385	385	352	357	365
Theoretical calorific power, calculated from analysis					472	366	403	414

* *Ibid.*, page 642.

The results are low, for the reasons already given; but, on comparing them with the calorific power of other power-gases given in Table III., it is evident, in spite of the dilution, that a very valuable power-gas is obtained.

TABLE III.—CALORIFIC POWER OF POWER-GASES.

Description of Gas.	British Thermal Units per Cubic Foot.	Description of Gas.	British Thermal Units per Cubic Foot.
Illuminating gas, London ...	641	Retort-oven gas:	
,, ,, Birkenhead .	746	Semet-Solvay	511
Carburetted water-gas	677	Lens Colliery	475
Producer-gas:		Otto-Hoffmann:	
Dowson	146	Illuminating gas, Glassport	685
Mond	145	Heating gas ,,	556
Dynamic	150	Illuminating gas, Everett	707
Wilson	150	Heating gas ,, ...	515
Blast-furnace gas	135	Water-gas	210

Horsepower to be obtained from Retort-oven Gas.—The actual horsepower to be obtained from the gas depends on the quantity as well as on the calorific power.

The primary use of the gas is to heat the ovens, and only the surplus is available for power-generation. It is necessary, therefore, to consider the conditions under which the maximum surplus of gas can be obtained. From the experience of recent years this would appear to depend on (1) the quality of the coal coked, (2) the suitability of the oven, and (3) whether the air going to the combustion-flues is heated before meeting the gas.

(1) *The Quality of the Coal.*—Lean coals, yielding comparatively small volumes of gas, and requiring the highest possible temperatures to be reached during the coking process, produce very little more gas than is required for burning in the flues, and sometimes the whole quantity has to be used for this purpose. But with good fat coal, which can be coked at somewhat lower temperatures, often from 20 to 40 per cent. of the gas produced remains, over and above that required for heating the ovens. According to Dr. Baum, however, it does not necessarily follow that those coals giving the highest proportion of gaseous products, such as the gas-coals, will yield a larger percentage of surplus than those less rich in volatile products. Often, the former require to be coked at a higher temperature than the latter, which entails a larger consumption of gas in the oven-flues and a corresponding reduction in the quantity of

the surplus. It may be, therefore, that in the former case there is, not a greater, but perhaps a smaller, quantity of surplus-gas available for power-generation than in the latter.

There is a minimum yield of volatile products below which it is impossible to obtain sufficient surplus for the profitable generation of power, and this limit is fixed by Mr. E. Reumaux* at coals yielding 20 per cent. of volatile products.

(2) *The Suitability of the Oven.*—In this respect, the main point is to obtain a uniformly high temperature in the coking mass. For this purpose, the regulation of the width of the oven to suit the class of coal that is to be coked, and the thickness of the walls separating the oven from the heating flues, are of importance. The width of the oven is solely determined by the character of the coal, the ovens being narrower for lean coals than for fat ones; and the walls of the ovens should be as thin as possible, consistent with durability of structure, in order that the heat may rapidly pass through the somewhat badly-conducting material of which the oven is built.

A third point of supreme importance is the even combustion of the gas in the heating flues. This can only be obtained by a proper distribution of the gas and air. In the early types of oven, the gas was admitted at one, or, at the most, at two or three points, where it met with air for its combustion, producing local overheating at these points; whilst it was a matter of great difficulty to obtain a sufficiently high temperature in other parts of the heating flues. The desirability of a greater distribution of gas and air has been fully recognized and the tendency in the more modern types of ovens is in this direction. Messrs. Otto & Company, have replaced the Otto-Hoffmann oven, in which the gas entered at a single jet under the sole-flue, by the Otto-Hilgenstock: in the earliest designs of the latter, gas was delivered at eight burners of Bunsen-type placed directly under the side-flues; but in the latest designs, the number of burners has been increased to twelve. The same principle was applied by Mr. Collin to ovens with horizontal flues, by dividing the flues in the middle by a mid-rib so as to form a front and back set of heating flues. Gas was admitted into the front and the back of each of these sets of flues simultaneously, whilst a similar admission of air at various points took place.

* *Trans. Inst. M.E.*, 1900, vol. xxi., page 402.

These pioneers in the subdivision of gas and air have been followed by most modern inventors, and in the latest types of ovens, such as the Kopper and Poetter ovens, each heating flue is separately supplied with gas and air. The gas enters each heating flue through a specially constructed nozzle into a combustion-chamber, where it meets with a supply of air for combustion; and the amount of gas entering each flue can be regulated until a uniform temperature is obtained throughout.

It would appear that the vertical heating flue lends itself more readily to this principle of subdivision than the horizontal flue, for in nearly all the more modern types the vertical flue is adopted.

(3) *Heating the Air, previously to its Meeting the Gas in the Combustion-flues.*—This has considerable influence on the amount of surplus-gas, for it must be remembered that the volume of air required for the combustion is at least ten times as great as that of the gas. The temperature of this volume of air has to be raised to the combustion-temperature in the flue. If cold air is admitted, the whole of the heat necessary to produce this temperature in the air must be generated at the expense of a certain quantity of the burning gas; but, if air previously heated to 1,200° Fahr., is introduced into the flues, a much smaller quantity of gas will suffice to raise the temperature of the air up to that of the flame.

Dr. Gasser points out that this principle was well illustrated when Messrs. Otto & Company abandoned the Otto-Hoffmann oven, with regenerators for heating the air, and adopted the Otto-Hilgenstock oven, in which the regenerators were dispensed with, and the air supplied to the burners was only slightly warmed by coming into contact with the hot walls of the structure carrying the oven. With the latter oven, the amount of surplus-gas was very small, or sometimes none at all; whereas with the former often a large supply was obtained.

In all the more recent types of ovens, the heating of the air is effected in large regenerators through the agency of the waste-heat in the gases that have been used for burning in the oven-flues, and, according to Dr. Baum, in this way, at least 20 per cent. of gas can be saved, if the air for combustion be previously heated to 1,300° Fahr. (700° Cent.).

The actual quantity of gas for power-generation that can reasonably be expected, after taking the above considerations into account, is variously stated by different authorities. Dr. Baum* states that from 20 to 40 per cent. of surplus-gas can be obtained from fat coals yielding from 9,800 to 15,000 cubic feet (280 to 450 cubic metres) per ton; Mr. E. Reumaux† considers that 25 per cent. of the total volume of gas may be obtained as surplus from Westphalian coal, whilst Mr. J. H. Darby‡ estimates that from 30 to 40 per cent. is available for power-generation, and Dr. P. P. Bedson§ quotes 30 per cent. as being obtained with Durham coal in Otto-Hilgenstock ovens. With the special arrangements adopted in America and Canada by the United Coke and Gas Company, for the supply of illuminating gas, from 44 to 50 per cent. of the gas is surplus.||

The writers made direct measurements of the available surplus-gas in the case of the ovens already mentioned. Two series of measurements were made under different conditions, extending over periods of 146 to 150 hours respectively. In the first series, the rate of supply was subject to considerable fluctuation; but it was much more regular in the second series. The average quantity per hour, however, was remarkably constant, as shewn in Table IV. These results are lower than those previously

TABLE IV.—QUANTITY OF SURPLUS-GAS FROM THE COKE-OVENS AT THE WHARNCLIFFE SILKSTONE COLLIERY.

Experiments.		A.	B.
Surplus-gas per hour at 32° Fahr. and a pressure of 30 inches	cubic feet	14,728	14,996
Duration of period of measurements ...	hours	146	150
Dry coal coked	tons	934	964
Surplus-gas per ton of coal coked	cubic feet	2,300	2,334
Estimated yield of gas per ton of coal ...	cubic feet	10,500	10,500
Surplus-gas available for power generation	per cent.	21·9	22·2

quoted, but they may be considered highly satisfactory, when one takes into consideration, firstly, that in addition to the gas used in the oven-flues, a portion is burnt directly under the boilers to assist in raising steam for working the plant, and this

* *Loc. cit.* † *Loc. cit.*

‡ *Royal Commission on Coal-Supplies*, Second Report, 1904, vol. ii., page 14.

§ *Ibid.*, page 109. || Dr. F. Schniewind, *loc. cit.*

quantity is not included in the above figures; and secondly, that no special means were taken to heat the air used for combustion.

Taking the average supply at 15,000 cubic feet per hour, and the heating value to be 365 British thermal units, the lowest estimate given in Table II., the theoretical horsepower is about 2,200; and assuming that only 20 to 25 per cent. of this can be directly used in the gas-engine, between 400 and 500 horsepower is available. It would, therefore, require about 30 to 37 cubic feet per hour to give 1 brake-horsepower, or from 13 to 17 horsepower per oven. Mr. E. Reumaux* gives for 120 ovens, with an available surplus of 18 per cent. of gas, 15 horsepower per oven.

Mr. Richard Pearson, in his evidence before the Royal Commission on Coal-supplies,† gives an estimate (Table V.) of the volume of different gases required to produce 1 brake-horsepower in any wellknown make of gas-engine.

TABLE V.—VOLUME OF GAS REQUIRED PER BRAKE-HORSEPOWER.

Description of Gas.	Consumption of Gas per Hour per Brake-horsepower.
	Cubic Feet.
Heathfield natural gas ...	12-15
Illuminating gas	20-25
Water-gas	60-80
Producer-gas	100-120

The gas requires theoretically 3 to 3·5 times its volume of air for complete combustion, and probably 6 or 7 volumes of air would have to be used for explosion in the gas-engine; for, with the theoretical quantity of air, a maximum temperature of about 5,000° Fahr. would be produced, which, with double the quantity of air, would be reduced to about 3,000° Fahr. These

TABLE VI.—MAXIMUM TEMPERATURES OF COMBUSTION OF POWER-GASES.

Experiments.	I. When burnt with the Theoretical Volume of Air.	II. When burnt with twice the Theoretical Volume of Air.
	Fahr. Degrees.	Fahr. Degrees.
Blast-furnace gas ...	3,100	2,000
Mond gas	3,500	2,150
Dowson gas ...	3,600	2,300

* *Loc. cit.*

† *Royal Commission on Coal-supplies*, Second Report, 1904, vol. ii., page 112.

temperatures are much higher than those obtained with producer- and blast-furnace gases, and are comparable with those obtained with town gas; hence the gases are suitable for use in the type of engine used with town or illuminating gas, and not in the types used with producer-gas or blast-furnace gases.

Purification of Coke-oven Gases.

When the gases leave the coke-oven they are conveyed to the bye-product plant, where they are cooled and freed from tar, ammonia and benzol, but whether they are sufficiently clean for use in a gas-engine after passing through that plant depends on its efficiency.

Usually, tarry matter in the form of fine spray is carried along with the gases; and whereas this is of no consequence when the gases are used for burning in the flues, or under the boilers, it constitutes a considerable detriment if they are passed in such a state directly to the gas-engine. For the tar adheres to the spindles of the valves, and prevents them from closing properly, which gives rise to back-firing; Mr. E. Reumaux* also states that it causes sooting in the cylinder. Apparently, the amount of this spray depends to a large extent on the efficiency of the cooling that takes place in the bye-product plant. If the temperature of the gases is reduced to 15° Cent. (60° Fahr.) before being scrubbed for ammonia and benzol recovery, then what spray is carried away in the gases is easily dealt with, but with inefficient cooling it is liable to cause trouble.

Under favourable circumstances, very simple appliances can be used, such as sawdust or coke scrubbers, through which the gas is passed on its way to the engine; but in some plants (as, for instance, the Otto-Hilgenstock plant), the spray is removed by means of a Pelouze-Audouin tar-separator before the gases pass to the ammonia-scrubber. In this separator, the gas is made to impinge in fine streams against baffle-plates, to which the tar adheres. A more recent invention for removing tar and dirt from the gases is the Theisen gas-washer, in which a very thin layer of gas is made to impinge against a thin film of water, which is carried round a spiral channel on a rapidly revolving drum, the gas travelling in the opposite direction to the water.†

* *Loc. cit.*

† *Engineering*, 1904, vol. lxxviii., pages 78 and 383.

TABLE VII.—RESULTS OBTAINED WITH THE THEISEN GAS-WASHER, WHEN USED TO CLEAN BLAST-FURNACE GASES.

Name of Works.	Volume of Gas per Hour.	Particulars of Gas. Entering. Dust per 100 Cubic Feet.	Entering. Temperature.	Entering. Moisture per 100 Cubic Feet.	Leaving. Dust per 100 Cubic Feet.	Leaving. Temp.	Leaving. Moisture per 100 Cubic Feet.	Water used. Temperatures. Entering.	Temperatures. Leaving.	Quantity. Per Hour.	Quantity. Per 100 Cubic Feet of Gas.
	Cubic Feet.	Grains.	Degs Fahr.	Grains.	Grains.	Deg. Fahr.	Grains.	Deg. Fahr.	Degs. Fahr.	Gallons.	Gallons.
				HOT GASES DIRECT FROM THE FURNACE.							
Hochdahl ...	602,000	260	291	760	1·7	86	300	57	102	4,134	0·7
Do. ...	420,000	260	316	103	0·8	99	214	45	104	2,625	0·6
Schalke ...	357,000	130 to 170	291	15 per cent. by volume	0·7	86	12 to 20 per cent. by volume	54	131	2,231	0·6
				COOLED GASES WITH THE HEAVY DUST SEPARATED.							
Horde ...	420,000 to 525,000	107	115	1,090	—	91	148	82	99	2,625 to 3,500	0·6 to 0·8
Do.	216,000	103	113	1,465	0·4	82	129	66	93	1,530	0·7
Rombach ...	315,000	85	109	1,800	0·8	97	—	64	66	2,231	0·7

The efficiency of these washers is shewn by the results recorded in Table VII.

There is no doubt that many difficulties will be avoided, if, at the outset, efficient means are taken to cool and cleanse the gas.

On the question of the removal of the sulphur and cyanogen, experts appear to hold different opinions. The quantity of sulphur in the gas is high, amounting to from 300 to 600 grains per 100 cubic feet. In the opinion of some authorities, it is essential that these should be removed, so as to prevent corrosion in the cylinder and valves by the sulphur dioxide produced during the explosion; whereas others hold that the gases, after the explosion, are so quickly scavenged out of the cylinder that there is little to fear from corrosion. This would appear to be justified by the experience of the Yorkshire Coal and Iron Company, Limited, who have had a 250 horsepower engine, fed with gas from an Otto-Hilgenstock retort-oven plant without special treatment for removal of sulphur, running for 18 months without any difficulty arising from corrosion. The writers hope that at some future date the members may be favoured with an account of the company's experience.

If it is deemed advisable to purify the gas from sulphuretted hydrogen, there are three processes available:—(1) Passing the gas over slaked lime; (2) passing the gas over oxide of iron; and (3) combining the two processes, and using both lime and oxide of iron.

The last is the most effective, as it removes sulphuretted hydrogen, carbon disulphide, and, to a certain extent, cyanogen. It entails, however, a somewhat extensive plant, which requires considerable attention and involves a good deal of labour in renewing the purifying material. The first method removes the sulphuretted hydrogen only, and is open to the objection that considerable nuisance attends the recharging of the purifiers, whilst there is much difficulty in disposing of the waste-lime, which, if allowed to accumulate, is a source of annoyance, owing to the evolution of sulphuretted hydrogen.

The second process would appear to be the best to adopt, for, although the purification from sulphur would not be so complete as in the third, still it would probably be sufficient for practical purposes, and in it a portion of the cyanogen would be removed;

whilst the spent oxide, when completely saturated with sulphur, is a marketable commodity, and can be sold to the sulphuric-acid maker to be used in the manufacture of sulphuric acid, or to German manufacturers for the recovery of the cyanogen.

With regard to the economy to be attained in using these gases for the generation of power, it must always be remembered that the gases are there in excess of what is required for working the bye-product plant, consequently, if not used for power-purposes, a portion of the heat-value of the fuel is wasted.

The distribution of the heat-value of the coal in the different products of the bye-product oven is given by Prof. P. P. Bedson* in his evidence before the Royal Commission on Coal-supplies, as follows:—

Heat used in coking:	
Total heat-value of coal	100
Coke	70
Waste-heat utilized	8
Heat used in coking coal, including loss by chimney, radiation, etc.	10
Surplus, as gas	4·4
Tar and ammonia	7·6

And according to Dr. Schniewind,† the distribution of the calorific power of the dry coal is as follows:—

Coke	72·2
Tar	4·1
Surplus-gas	12·7
Heating gas	10·7
Ammonia liquor	0·3

Assuming that 23 per cent. of the heating-value of the coal is represented by the gases, then in the case of the gases referred to in the early part of this paper, 5 per cent. of the heating value of the coal is wasted, which is represented by about 450 horsepower on the assumption that only 20 per cent. of the theoretical heat-value of these gases can be used.

Now, the fuel-consumption per horsepower per hour depends on the efficiency of the engine; and in colliery-engines of non-condensing type it is probably about 6 to 7 pounds. To develop 450 horsepower, therefore, entails a consumption of 2,700 pounds, or say 1 ton of coal saved per hour, which is equal to 7,200 tons

* *Royal Commission on Coal-supplies*, Second Report, 1904, vol. ii., page 108.

† *Loc. cit.*

saved in a year of 300 working days. Taking the output at 500,000 tons per annum and the colliery-consumption equal to 6 per cent. of the output, this amounts to 24 per cent. of the total coal-consumption; and at 4s. 6d. per ton it amounts to £1,600 per annum; but with more efficient engines consuming only 3 pounds of coal per brake-horsepower, this amount would be reduced to one-half.

Use of Producer-gas.

Though not falling strictly within the scope of this paper, a few words may be acceptable with regard to the third alternative source of power, namely, producer-gas for use in the case of non-coking coals. Many manufacturers have adopted gas-producers as being more economical than the steam-boiler, probably to the extent of 7 per cent., all things being equal.

It is necessary, however, to distinguish between producers suitable for non-bituminous coal, and those suitable for bituminous coal.

The former class, including the Dowson and similar producers, are worked with anthracite-slack, the value of which at a great distance from the base of supply (say 22s. per ton in Yorkshire) has to be compared with the value of a cheaper fuel on the spot (say 4s. 6d. per ton) which can be worked in the second class of producers, such as the Mond, Mason, and others.

The inducement would be, therefore, to erect a Mason or Dynamic producer at a Yorkshire colliery, whereas at a South Wales colliery, with anthracite, say, at 8s. per ton, the Dowson type would be selected.

Besides the economy in the heating value of the gas-plant as compared with the steam-plant, there is a notable saving in the cost of working the two plants to the extent of about 16 per cent., and this is still further increased when the quantity of power required allows of the recovery of ammonium sulphate which is so strongly advocated in the Mond, Duff, and other producers. It is found, however, that 1,000 horsepower, or perhaps a still larger unit, is the minimum for which it will pay to erect one of these costly plants.

Assuming that the quantity is sufficiently large, which undoubtedly it is at many collieries, it is possible to get as much for ammonium sulphate, at present prices (£12 per ton), as

represents 4s. 6d. per ton on the coal carbonized. This would be an important economy at collieries where the coal cannot be coked, but is suitable for use in this kind of producer.

The range of such coals is limited, for with the improvements for obtaining very high temperatures in retort-ovens, and the use of the compressor for charging, it is possible to coke much leaner and poorer coals than heretofore; and the value of the coal coked with recovery of bye-products being about 12s. 6d. per ton, would yield about 8s. per ton on the coal put into the oven as compared with 4s. 6d. per ton on the coal carbonized in the Mond or Duff producer. As a set-off to this, it must not be forgotten that, probably with coal yielding less than 20 per cent. of volatile products, there will be no surplus-gas, and that a much larger volume of gas per ton of coal carbonized is available from the producer than from the coke-oven.

Gas-engines.

Gas-engines, or, as they are more correctly termed, internal combustion-motors, are very much more efficient in the generation of power from a given number of heat-units than any steam-engine. The principal cause of this is, that in the gas-engine the power created by the explosion of gas and air takes place in the cylinder itself, and the force is applied directly to the piston. In a steam-engine, however well designed, the loss from a variety of causes is so great that if 10 per cent. of the power in the coal is converted into work, it is considered a very good result indeed. Mr. Henry McLaren, of Leeds, stated in his evidence before the Royal Commission on Coal-supplies that "All engineers are aware that the steam-engine, at its best, is a very crude arrangement for converting heat into power."* He gives the statement of heat-losses shewn in Table VIII.

Mr. McLaren states that "8·87 per cent. of the heat in the coal converted into power at the engine appears to be a very poor result; but if all condensing engines throughout the country did equally well, and non-condensing engines in the same proportion, considerably over 50 per cent. of the engine-fuel now used would be saved." He thinks that all engines not capable of working on 3·2 pounds of coal per brake-horsepower should be "scrapped." Colliery-engines probably, on the average, con-

* *Royal Commission on Coal-supplies*, Second Report, 1904, vol. ii., page 333.

sume 8 pounds of coal per horsepower, or twice as much as Mr. McLaren says should be the maximum.

TABLE VIII.—HEAT-LOSSES OF STEAM-ENGINES.*

	British Thermal Units.	Percentage of Total Heat in Coal.
Loss through bars	135	1·00
,, by radiation from the boiler	675	5·00
,, in chimney-gases	2,970	22·00
,, radiation from the main steam-pipes ...	210	1·56
,, radiation from the auxiliary pipes ..	30	0·22
,, in auxiliary engines exhaust	190	1·40
,, in radiation from the engine	280	2·08
,, in engine-exhaust	7,737	57·31
,, engine-friction	76	0·56
Total losses	12,303	91·13
Heat converted into brake-horsepower	1,197	8·87
Total heat in the coal	13,500	100·00

One must guard against taking comparisons of the relative efficiency of gas-engines and condensing steam-engines of the highest type, such as are used in electric-lighting stations, as such engines are about three times as efficient as the average colliery-engine. No doubt there is at every colliery a considerable quantity of unsaleable fuel, such as screen-pickings and inferior coal, which can be burnt to raise steam by forced draught or other special appliances; but this is not, as a rule, enough to furnish half the colliery-consumption, and consequently good merchantable coal or slack is used in large quantities. Nor is the value of the fuel the only consideration in the raising of steam, for the labour of stokers is a very expensive item; and the worse the fuel, the greater the expense in labour, because the fires require cleaning so much oftener. With gas-engines there is a minimum of labour. There is, consequently, every inducement, in laying out a new colliery, to provide for the generation of all the secondary power required, especially where it is proposed to use electricity underground, and to consider the provision of a plant in which gas would be the motive power.

Assuming, then, that gas-power is adopted, a few general remarks on the subject of gas-engines may be acceptable. It has been pointed out, in the earlier part of this paper, that there

* *Power*,

is a very wide difference between the explosion-temperatures of various power-gases. Thus, blast-furnace gases have a maximum theoretical temperature of about 3,100° Fahr.; Dowson producer-gas, 3,600° Fahr.; Mond producer-gas, 3,500° Fahr.; and coke-oven gases from Silkstone coal, 5,000° Fahr. It is clear, therefore, that engines which work well on blast-furnace gas may be quite unsuitable for coke-oven gas.

The great difficulty in the working of large gas-engines is the high temperature produced in the cylinder. The bigger the cylinder, the larger the volume of mixture to be exploded, and the greater the total amount of heat generated. There is a limit to the permissible temperature, namely, about 3,300° Fahr. (1,800° Cent.), as above this point pre-ignition is likely to take place. This is one of the worst things that can happen to a gas-engine, as it throws a prodigious strain on all the parts. Besides this, cylinders and pistons are liable to crack, for they are working at almost red heat; and, to meet this, the cylinders and pistons, and even the valve-boxes, are water-cooled by elaborate jacketting. One must not, therefore, conclude that because one hears of very large gas-engines being at work, say, from 1,000 to 3,000 horsepower, that such engines are available for use with coke-oven gases. As a matter of fact, engines of about 250 horsepower, and cylinders, 24 inches in diameter, may be regarded as the maximum for use with coke-oven gases.

There are two principal classes of gas-engines. The Otto or four-cycle type, and the Clerk or two-cycle type. The former is by far the commoner, but the latter is employed in many of the larger engines recently designed. By using two cylinders, either side by side, opposite, or in tandem, the effect of a two-cycle engine may be secured: that is to say an impetus is given to the crank-shaft every revolution, instead of every second revolution. In this way, an engine of 500 horsepower may be arranged.

The Otto or four-cycle consists of four operations: (1) Forward stroke (suction), during which the gas-mixture is sucked into the mixing-chamber, and the back-end of the cylinder; (2) back stroke (compression), during which the mixture is compressed by the returning piston; (3) forward stroke (work), when the explosion of the gas-mixture gives impetus to the

piston; and (4) back stroke (exhaust), during which the exhaust-valve opens, and the cylinder is cleared of the products of combustion. It thus takes four strokes or two revolutions to go through the Otto cycle, the cylinder being used alternately as a pump and a motor. The valves are of the conical-seated lift type, and are four in number: charge inlet-valve, gas inlet-valve, igniting-valve, and exhaust-valve. The valves are actuated by cams and levers from a horizontal shaft, which rotates parallel to the cylinder, and is geared to the crank-shaft.

The following well-known gas-engines operate on the Otto cycle, with various modifications in detail:—Crossley, Deutz, National, Premier, Westinghouse, and many others. They are, however, usually associated with the double-acting engine or Clerk cycle. Of the Clerk-cycle type, there are the Cockerill, Körting, Oechelhauser, and others, all of which have been made in very large sizes, but all intended for use with blast-furnace or producer-gases. There does not appear to be any very great advantage, so far as collieries are concerned, in using very large engines. A pair of 250 horsepower engines developing 500 horsepower are quite large enough, and, having regard to the serious consequences of an interruption of work, it seems distinctly advisable to reduce the size of the units and increase their number.

The subject of gas-engines is too large to be further treated here, but within the present year, Mr. Dugald Clerk has delivered a series of four Cantor lectures before the Society of Arts, in which the whole subject is treated in the most up-to-date manner, and to his lectures we would refer those who desire to acquaint themselves with the subject.*

Whilst writing the above paper, an article on the same subject appeared in an American journal, in which it is stated that amongst others, the following large engines (Table IX.) are being fed with coke-oven gases.

The John Cockerill Company, Seraing, Belgium, have installed three engines at their works, to be fed with coke-oven gases. Further, it is contemplated by the Lackawanna Steel Company, Buffalo, New York, to use the gases from the coke-

* "Internal Combustion Engines," *Journal of the Society of Arts*, 1905, vol. liii., pages 870, 888, 905 and 923.

oven plant which they are now erecting, to drive blowing-engines of 2,000 horsepower.

TABLE IX.—LARGE GAS-ENGINES WORKED WITH COKE-OVEN GASES.*

Where Working.	Type of Engine.	Horse-power	Number of Engines.
United Coke and Gas Company, Camden, New Jersey	Three-cylindered Westinghouse	Not stated	—
Yorkshire Iron and Coal Company, Ltd., Tingley	Cockerill	250	2
Graf Larisch-Mönnich'sche Colliery, Karwin, Moravia	Marienfelde	600	1
Witkowitz Colliery Company, Polnisch-Ostrau	Dessau, single-acting, four-cylindered twin-engine	300	3
Carolinen Schacht	Cockerill, single-acting, four-cylindered twin-engine	250	1
Neunkirchen, Saar	Not stated...	200	1
Minster Stein Colliery	,, ...	125	1
Lothringen Colliery	,, ...	350	1
Beuthen, Upper Silesia	Körting	300	4
Borsig Works	Not stated...	600	1
Pluto Colliery, Gelsenkirchen ...	Deutz, single cylinder ...	Not stated	2

* *Power*, 1905, vol. xxv., page 129.

Mr. W. N. DREW wrote that for more than 16 years, at the Thorncliffe collieries, all the steam required had been raised by the surplus gases from modified beehive coke-ovens. This gas resembled that of blast-furnace gas in composition, and contained 75 per cent. of nitrogen. Although a time might come when all coke would be made in bye-product retort-ovens, it should not be forgotten that there was great irregularity in the values of the bye-products, on the sale of which the success of such expensive and delicate plants was largely based. When the carbonizing works with which he (Mr. Drew) was connected were put down, benzol was worth 6s. 6d. per gallon, it is now worth 9d.; similarly, sulphate of ammonia, then worth £14 per ton had since been as low as £6 10s.; and the enormously increasing output made it unlikely that the present high price would be maintained. With benzol at its present price, he (Mr. Drew) suggested that it would be more profitable to scrub the gas only for ammonia, and to leave the benzol in the gas to be used as fuel in the gas-engine.

Dr. G. A. Meyer (Westphalia) wrote that at the Schlägel and Eisen III. and IV. collieries, there were 60 bye-product ovens using 330 tons of coking coal every 24 hours, and producing 75 per cent. of coke. The volume of gas, over and above that required to heat the coke-ovens, was 937,000 cubic feet (26,530 cubic metres) every 24 hours, at a pressure of 2·36 inches. The heat from the coke-oven flues was passed under 7 boilers, with a heating surface of 1,000 square feet each. With the temperature of the feed-water at 61° Fahr., the quantity of water evaporated was 67,760 gallons (306 cubic metres) in 24 hours, equivalent to 4·10 gallons per hour: the steam-pressure being 100 pounds per square inch.

The President (Mr. T. W. H. Mitchell) moved a vote of thanks to Messrs. G. B. Walker and L. T. O'Shea for their interesting paper.

The vote was cordially approved.

Mr. J. Clegg read the following paper on a "Safety-catch for Cages."

SAFETY-CATCH FOR CAGES.*

By JOSEPH CLEGG.

The safety-catch, of which a model is shewn, is applicable to mine and other similar cages, and it is intended to prevent the cage from falling, in the event of the winding-rope breaking or becoming accidentally detached. In either case, the safety-catch would immediately stop the cage, and hold it in position.

Fig. 1.—Elevation of the Safety-cage, hanging from the Winding-rope.

Connected with each conductor and bolted to the uprights of the cage is a device, which is worked on the eccentric principle, and takes up no more room than the ordinary slides. There is a short lever, with one end in the shape of the cam on the crank-shaft of an engine. This works on a pin, and presses against a block. When the cage is descending, the conductors are relatively ascending, the cage and the conductors are working against each other. The other end of the lever is attached by means of a small chain to each corner-chain of the cage, so that, when the cages are working in the ordinary way, the catches are out of touch with the conductors. But the instant the rope breaks, the chains slacken, the levers drop and put the catches into such a position that they cause a perfect jam between the cage and the conductors, and the heavier the cage, the more tightly do they grip.

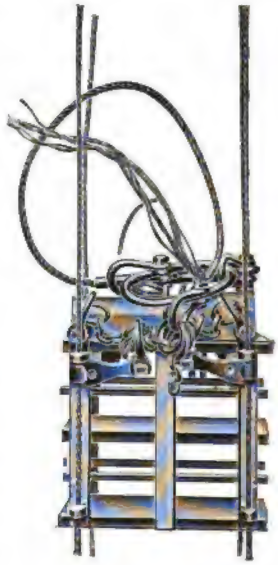

Fig. 2.—Elevation of the Safety-cage, detached from the Winding-rope.

* British Patent, 1904, No. 19,433, Mr. Thomas Moody and Mr. Joseph Clegg.

DISCUSSION OF MR. M. H. HABERSHON'S PAPER ON "THE WORK OF A JOINT COLLIERY RESCUE-STATION."*

Mr. M. H. Habershon said that since the paper was read, they had succeeded in producing a smoke-mixture in the experimental station, and were now able to give men practice in a noxious atmosphere. Only a few days ago, some apparatus was received from the makers of the Giersberg pneumatophore, which was found to be superior to the apparatus exhibited when the paper was read. Men who could not use the former apparatus, were able to use the new one for ½ hour, on even the first occasion. He (Mr. Habershon) hoped that shortly an opportunity would be afforded of testing and using the apparatus in a noxious atmosphere underground, where there was no ventilation whatever. All their experience, since the paper was read, had been most encouraging, and confirmed the opinion that it only required practice to wear the pneumatophore for a satisfactory length of time.

Mr. J. Wroe's paper on "The Effect of the Watering of Coal-mines on the Spread of Ankylostomiasis" was read as follows:—

* *Trans. Inst. M.E.*, 1904, vol. xxviii., page 254.

THE EFFECT OF THE WATERING OF COAL-MINES ON THE SPREAD OF ANKYLOSTOMIASIS.

By JONATHAN WROE.

A great deal of interest has been taken by the members in the miners' worm-disease, and as to whether the introduction of a system of damping the working-places, with a view to reducing the liability to the spread of explosions by dry coal-dust, is responsible for the spread of the disease. Various opinions have been held on this point, and some experiments made by Mr. Lüthgen, manager of the Julia and Von der Heydt collieries, Herne, Westphalia, recently published, are worthy of careful attention.*

Mr. Lüthgen obtained the permission of the Government authorities to suspend watering the workings of the Julia colliery for twelve months, from March 9th, 1903, to March 1st, 1904; and the results obtained in that colliery were compared with those of the adjacent Von der Heydt colliery, where the conditions were very similar, but where the watering regulations were in operation.

At both collieries, there has been a marked reduction of the disease, due no doubt to the stringent regulations now in force at all German collieries with regard to the isolation and medical care of infected persons; but, as will be shewn hereafter, the reduction was much greater at the mine, in which the watering was suspended than in that where it was continued. Experiments were also made in the Recklinghausen I. and II. collieries with similar results.

Mr. Lüthgen stated that "there was no water-sprinkling at the Julia colliery from March 9th, 1903, to March 1st, 1904. It was several months before the mine could be said to be perfectly dry, and as small feeders of water were met with in different parts of the mine, they were treated with milk of lime, so as to disinfect them as far as possible."

* "Über den Einfluss der Berieselung auf die Ausbreitung der Wurmkrankheit," *Glückauf*, 1905, vol. xli., page 365.

Eleven examinations of the workmen employed in the Julia and Von der Heydt collieries (Tables I. and II.) were made at various times throughout the year. At the commencement of the experiments, out of the 1,168 men employed at the Julia colliery 19·52 per cent. were suffering from ankylostomiasis, and

TABLE I.—JULIA COLLIERY.

No. of Examination.	Period of Examinations.	No. of Men Examined.	Workmen Infected.	
			No.	Percentage.
1	Dec. 17th, 1902, to Feb. 16th, 1903 ..	1,168	228	19·52
2	Feb. 16th, 1903, to March 28th, 1903 ...	1,160	153	13·19
3	March 30th, 1903, to April 18th, 1903 ...	1,079	87	8·06
4	April 20th, 1903, to May 5th, 1903 ...	1,103	40	3·63
5	May 11th, 1903, to June 3rd, 1903 ...	1,098	44	4·00
6	June 4th, 1903, to July 16th, 1903 ..	1,093	51	4·67
7	July 17th, 1903, to July 31st, 1903 ...	267	13	4·87
8	August 10th, 1903, to Sept. 11th, 1903 ...	242	9	3·72
9	Oct. 15th, 1903, to Nov. 30th, 1903 ...	1,105	10	0·90
10	Jany. 25th 1904, to March 12th, 1904 ...	1,088	16	1·47
11	July 19th, 1904, to Aug. 6th, 1904 ...	1,063	10	0·94

17·89 per cent. of the 928 men employed at the Von der Heydt colliery. The examinations shew that as the number of men affected by the disease had decreased from 228 men, or 19·52 per cent., to 10 men, or 0·94 per cent., at the Julia colliery, within the same period, the number had decreased from 166 men, or 17·89 per cent., to 13 men, or 1·47 per cent., at the Von der Heydt colliery.

TABLE II.—VON DER HEYDT COLLIERY.

No. of Examination.	Period of Examinations.	No. of Men Examined.	Workmen Infected.	
			No.	Percentage.
1	March 10th, 1903, to April 27th, 1903 ...	928	166	17·89
2	April 28th, 1903, to June 8th, 1903 ..	894	80	8·95
3	June 9th, 1903, to July 15th, 1903 ...	926	63	6·80
4	July 16th, 1903, to August 22nd, 1903 ...	910	48	5·27
5	August 24th, 1903, to Oct. 14th, 1903 ...	930	25	2·69
6	Nov. 11th, 1903, to Dec. 2nd, 1903 ...	890	19	2·13
7	Dec. 14th, 1903, to Jany. 2nd, 1904 ...	221	13	5·88
8	Jany. 5th, 1904, to March 9th, 1904 ...	205	17	8·29
9	March 14th, 1904, to April 20th, 1904 ...	898	31	3·45
10	April 26th, 1904, to June 10th, 1904 ...	928	20	2·15
11	August 22nd, 1904, to Oct. 22nd, 1904 ...	886	13	1·47

It is thus clearly shewn that the examinations at the Julia colliery, where the sprinkling had been stopped, yield more favourable results than those at the Von der Heydt colliery; and it is specially indicated when the details of the results of the ninth, tenth and eleventh examinations are com-

pared. In the ninth examination at the Julia colliery, 10 men were found to be affected, and only one was proved to have been infected in that pit. In the tenth examination at the Julia colliery, out of 16 persons affected, one only had previously suffered from ankylostomiasis. This man had returned from his military service in October, 1903, and was employed at the colliery at that time: he had neither produced worm-eggs at the time of his engagement, nor for six weeks afterwards. There was, however, a possibility that the man was already affected by the disease at the time of these two examinations, without the fact being detected by the doctor. At the eleventh examination, 10 persons were found to be affected; it was stated that they had suffered from it several times previously, except a trammer, who had been engaged on July 4th, 1904, and was found to be suffering from the disease on August 2nd, 1904. It

TABLE III.—RECKLINGHAUSEN I. COLLIERY.

No. of Examination.	Period of Examinations.	No. of Men Examined.	Workmen Infected.	
			No.	Percentage.
1	April 4th, 1903, to May 27th, 1903 ...	1,141	144	12·76
2	May 29th, 1903, to July 16th, 1903 ..	1,136	123	10·83
3	July 17th, 1903, to Oct. 29th, 1903 ...	1,163	82	7·05
4	Sept. 2nd, 1903, to Jany. 9th, 1904 ...	1,146	38	3·31
5	Jany. 11th, 1904, to March 9th, 1904 ...	1,208	36	2·98
6	March 10th, 1904, to June 25th, 1904 ..	1,306	52	3·98
7	June 27th, 1904, to August 25th, 1904 ...	1,239	32	2·58
8	August 26th, 1904, to Oct. 12th, 1904 ...	1,227	30	2·44
9	Oct. 13th, 1904, to Nov. 30th, 1904 ...	1,199	33	2·75
10		1,006	29	2·88

was, however, very unlikely that this man was infected at the Julia colliery, for the development of the eggs could hardly have taken place in so short a time; besides, the man said that he had not been working in a pit for some time previously, but he had been employed at the Friedrich der Grosse colliery in 1900.

At the Von der Heydt colliery, in the ninth, tenth and eleventh examinations, 31, 20 and 13 men respectively were found to be suffering from the disease: 11, 7 and 6 men respectively being found to be affected for the first time. It is evident, therefore, that the stopping of the sprinkling had a disinfecting effect, and that the continuation of the sprinkling had largely assisted in the extension of the disease.

This opinion was further confirmed by the results of the examinations (Tables III. and IV.) at the Recklinghausen I. and II. collieries.

At the first examination at Recklinghausen II. colliery, only 3·7 per cent. of the men were found to be suffering from ankylostomiasis, whilst at the neighbouring Recklinghausen I. colliery not less than 12·76 per cent. of the men were affected. The conditions at Recklinghausen II. colliery are more favourable for the spread of ankylostomiasis, in consequence of the seams being steeper and the temperature being higher than at Recklinghausen I. colliery, and also from the workings being packed at the former colliery. It should, however, be taken into consideration that no watering had taken place in the gas-coal district, and few persons had been found to be affected amongst the men employed therein. Further examinations have confirmed the fact that the liability of infection is less at No. II. than at No. I. colliery. At Recklinghausen II. colliery, after six examinations (the first two being made only once with each man), they succeeded in reducing the number of the affected men from 3·7 to 0·22 per cent. At Recklinghausen I. colliery, after four examinations, the number of affected men was reduced from 12·76 to 3·31 per cent.; but the percentage remained stationary in the six further examinations.

TABLE IV.—RECKLINGHAUSEN II. COLLIERY.

No. of Examination.	Period of Examinations.	No. of Men Examined.	Workmen Infected.	
			No.	Percentage.
1	April 4th, 1903, to June 15th, 1903 ...	1,425	53	3·70
2	June 16th, 1903, to Sept. 3rd, 1903 ...	1,499	32	2·10
3	Sept. 4th, 1903, to Feb. 29th, 1904 ...	2,010	47	2·30
4	March 1st, 1904, to May 21st, 1904 ...	1,784	24	1·34
5	May 24th, 1904, to Sept. 6th, 1904 ...	1,826	14	0·77
6	Sept. 9th, 1904, to Nov. 19th, 1904 ...	1,766	4	0·22

Mr. J. S. BARNES' paper on "The Automatic Prevention of Overwinding of Hoisting, Winding and Haulage-engines or Motors" was read as follows:—

THE AUTOMATIC PREVENTION OF OVERWINDING OF HOISTING, WINDING AND HAULAGE-ENGINES OR MOTORS.

By J. S. BARNES.

The apparatus described in this paper consists of a combination of mechanical and electrical appliances so arranged as to prevent overwinding.* The electromagnets, MM, must exert sufficient force to attract the armature, A, when the circuit is closed. The armature must be fixed on bearings, having a minimum of friction. This object is attained by using pivot-bearings, PP, which allow the armature to move freely, and respond to the magnetic inductive action of the electromagnets; thus the movement of the armature can be regulated by means of the screws, JJ, and H, (Figs. 1 and 2, Plate VI.). The electromagnets are enclosed in a case, CA, so as to protect them from dust, dirt or injury.

The terminals, TT, are connected by means of wires, W, to the battery or dynamo, BD, and to the finger-pointer, FP, of the indicator-dial, ID. Suitably insulated contacts, CC_1, secured to the indicator-dial, are connected by wires with the battery, passing through the switch, SW.

The armature, A, is provided with a lever, L_3, projecting out of the box, and working the lever, L, which is supported on the brackets, R and S.

The lever, L_5, with a weight, ZZ, is connected to a steam-valve, XX, and suitably supported on a knife-edge, Y, and provided with guides, G.

The lever, L_1, representing either the main stop-valve, or the reversing-lever of the engine (depending upon the lever used by the winding-engineman to stop and to start the engine), is coupled to the switch, SW, by means of a link, L_2.

The valve, XX, independent of the main stop-valve, is fitted with one or more valves and seats, and is connected to the steam-supply pipes in the most convenient position.

* British Patent, 1902, No. 24,390, Mr. John Shaw Barnes.

In the case of electric winding, suitable connections are made to a switch, OO, which breaks the supply-circuit from the motors.

Should the engineman or motorman fail to shut off steam from the engine, or current from the motor, at the proper place, overwinding is prevented by the finger-pointer, or other suitable means closing the circuit, making contact with the insulated studs on the dial, causing a current of electricity to pass from the battery, or other source of electrical supply, and thereby magnetizing the electromagnets, which attract the armature through the distance, X, and move the lever connected with it at the same time. The lever, L, is thus caused to turn on its fulcrum and withdraw the knife-edged support, Y, from the weighted valve-lever. The valve-spindle drops and, at the same time, the valve-seat, XX, is closed, and the valve-seat, NN, is opened. The valve, XX, stops the supply of steam to the winding-engine, and opens the valve admitting steam to the brake.

The electric service is operated in a similar manner: the switch, OO, being opened, the supply of electric energy is cut off.

The switch, SW, is operated every time that the engineman starts and stops the engine, breaking the circuit on stopping, and making the circuit on starting. It is opened just before the finger-pointer makes contact, by pulling the lever, thus breaking the circuit at the switch, SW, at the same time as the circuit is about to be closed on the indicator-dial.

An electric bell can be arranged to warn the engineman, when steam should be shut off, if required.

When the engineman is decking the cage, another set of contacts can be arranged on the indicator, so as to close the circuit electrically should the cage reach a certain position above the decking-landing.

When the finger-pointer is travelling backwards, arrangements can be made to keep the circuit open whilst the finger-pointer is passing over the contacts, by applying the principle of the make-and-break usually adopted in the ordinary mechanical bell-striking arrangement, which is fixed to nearly every indicator. Thus the apparatus is prevented from coming into action.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, APRIL 3RD, 1905.

MR. W. N. ATKINSON, VICE-PRESIDENT, IN THE CHAIR.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. SATIS CHANDRA DE, Mining Engineer, The University, Birmingham.
Mr. GEORGE FAIRBAIRN, Mine-surveyor, Cannock Chase Colliery, Walsall.
Mr. T. W. H. LAVERICK, Mining Engineer, Newdigate Colliery, Nuneaton.
Mr. P. K. MAJUMDAR, Mining Engineer, The University, Birmingham.
Mr. GEORGE DOUGLAS SMITH, Consulting Engineer, 3, Newhall Street, Birmingham.

STUDENT—

Mr. WILLIAM ALDERSON, Surveyor, Oakham Road, Dudley.

Mr. JOHN FOX's paper on "Tapping and Running-off a Head of Water from a Shaft" was read as follows:—

TAPPING AND RUNNING-OFF A HEAD OF WATER FROM A SHAFT.

By JOHN FOX.

The water to be run off was in the No. 2 shaft, Littleton collieries, and it was found that the only possible way to drain it off was by a heading driven from the No. 3 shaft, to within 50 feet of No. 2 shaft, and to tap the water by a bore-hole. The No. 2 shaft had been sunk a considerable time before the No. 3 shaft, and going down to the Deep coal-seam, a great portion of the shaft formed a sump for a large quantity of the water made in the dip-workings of the No. 2 shaft, which lay a considerable distance above the Deep coal-seam, and it was estimated that about 600 feet of water had to be run off. The water was run off because the lower portion of the No. 2 shaft was required for use as a return-airway for the No. 3 shaft headings while opening out the workings, and for driving communication-roads.

The heading was driven to within 50 feet of the No. 2 shaft containing the water, and then it was opened out from 6 feet high and 6 feet wide to 6 feet high and 10 feet wide, so as to form a strong abutment for an intended water-dam to be built therein. The heading was a cross-measures drift, the ground consisting of sandstone and strong blue binds intermixed with ironstones, etc., which made boring very difficult.

After bearings had been taken to ensure that the bore-hole would fairly strike the centre of the shaft, the boring was proceeded with. A hole was bored 14 feet long and 2½ inches in diameter; this was enlarged for a length of about 8 feet to 3¾ inches in diameter, so as to take a pipe 3½ inches in diameter. The bore-hole for the first length of 8 feet was lined with a pipe 3½ inches in diameter; it was then reduced by means of a reducing-box screwed to the inner side of the pipe, to a diameter of 2½ inches, and driven for a length of about 4 feet tightly into the bore-hole. At the other end of the larger pipe, a gland,

4½ feet long, was fixed and built into the dam, so as to prevent the pipe from being forced out by the great pressure of the water.

The next operation was the building of the dam, which was built with good dry bricks, and the mortar was mixed with cement so that it would adhere firmly to the surrounding rock-surfaces. This dam was allowed to remain a few days, so that it might become thoroughly dry before boring operations were resumed. A valve was then put on the end of the larger pipe, and the further boring of the hole was completed through this valve. The boring was rather difficult from various reasons, one being the springing of the rods between the machine and the inner end of the hole. The Elliott stand boring machine was used, fitted with a few special contrivances to suit the occasion.

When the walling of the shaft was bored through, the rush of water was so great that it forced the rods, for a considerable distance, out of the hole; and, when they were completely withdrawn, the volume of water was so great that a stream, 6 or 7 inches deep, flowed down the bottom of the heading. The pressure on the dam was so great that the water came through it in the form of a fine spray, for a short time. When the dam was removed, after the water had been run off, and the heading advanced along the line of the bore-hole, it was found that the erosive action of the water had enlarged the hole, where unprotected, until, in places, it was from 18 to 24 inches in diameter.

Mr. W. N. Atkinson said that, although the operation of tapping a large head of water, as described by Mr. Fox, had been successful, yet it appeared that some risk had been run, as shewn by the manner in which the water had forced itself through the dam in the form of fine spray and also by its erosive action on the bore-hole, owing to the excessive pressure. It would have been an advantage to have employed a machine, which would have permitted the testing of the pipes and bore-hole with the machine in position: the machine being fitted with a valve for closing the bore-hole. The Burnside, a good example of this type of machine, had been described in the *Transactions*.*

Mr. J. Liddell said that he had recently been boring against

* "Tapping Drowned Workings at Wheatley Hill Colliery," by Mr. W. B. Wilson, jun., *Trans. Inst. M.E.*, 1902, vol. xxiii., page 72.

a head of water, at a pressure of 250 pounds per square inch, through bore-holes, 2½ inches in diameter. He had employed the Burnside machine with complete satisfaction, and was able to test the bore-holes, which were lined with tube, up to a pressure of 300 pounds per square inch before the boring was commenced.

Mr. W. N. Atkinson moved a vote of thanks to Mr. John Fox for his paper.

Mr. Isaac Meachem seconded the resolution, which was unanimously approved.

DISCUSSION OF MR. LAURENCE HOLLAND'S PAPER ON "PROBLEMS OF WORKING THICK COAL IN DEEP MINES."*

Mr. F. C. Swallow (West Cannock colliery) said that the mining difficulties attendant upon the profitable and safe working of the thick coal-seams of South Staffordshire and parts of Warwickshire were greater than would appear to be the case, and it would greatly enhance the practical value of the paper if comparative costs of working per ton and also comparison of the waste in working the Thick coal-seam as compared with seams, 6 feet and under, in thickness, having varying conditions of roof and floor, were submitted.

Table II., showing how the air takes up the heat and moisture in travelling through a thick coal-seam, was one of much interest. It would appear that its practical value is in suggesting, when working a thick coal-seam at great depth, and a coal whose natural temperature was 74° Fahr., that the intake-roadways, at any rate, should be driven no larger than is just necessary for a single line of tub-road and of sufficient area to provide adequate ventilation. He (Mr. Swallow) had worked thick coal-seams, and the roadways were driven in the fire-clay immediately under the coal: the retreating longwall system of working the seam being adopted. The distance away from the pit-bottom to which these roads were driven was about 2,700 feet, and although he had not ascertained the actual temperature of the air, this was by no means excessive, and it would not exceed 60° Fahr.: the fire-clay sides of the headings being naturally quite cool. But, immediately upon entering the work-

* *Trans. Inst. M.E.*, 1905, vol. xxviii., page 349.

ing stalls, where the area of the airway was much larger, the working-places were found to be very warm, this excessive heat being doubtless caused by the higher temperature of the coal. The principal difficulty, however, that had to be faced in adopting the above method was the great initial cost of winning out the coal-seam; and few companies could afford to sacrifice both time and money to win out the coal-face on this system, more especially if great outlay had been involved in sinking deep and expensive shafts.

The difficulty of working thick coal-seams profitably, under average trade-conditions, is also greater where the seam is lying horizontal than when lying at a gradient up to 20 degrees; because, in the latter case, the retreating system of working can be adopted and the water run into the goaf on the deep side of the coal-faces, thus completely closing up the wastes and preventing gob-fires. In the former case, however, the sides-of-work system as mentioned in the paper, or some similar system of working, has to be adopted.

He (Mr. Swallow) agreed with Mr. Holland that compressed air could be very profitably employed, both for power-purposes and ventilation, in working thick coal-seams, and would greatly mitigate the evils of heating due to heat given off from the sides and roof of the coal-seam when roads are driven in the coal; but air-mains of from, say, 6 to 10 inches in diameter, should be used to convey the compressed air to the various districts instead of the small pipes mentioned in the paper.

Mr. W. N. Atkinson said that the higher temperature of the air in the working-places, as compared with that where the roads were driven in fire-clay and were quite cool, was attributable to some extent to the absorption of oxygen by the coal, which developed heat. The method of flushing débris into the goaf (the water draining off and leaving a solid mass), where it could be employed, possessed considerable advantages, but he was not prepared to say that it could be adopted in flat seams.*

Mr. Isaac Meachem thought that the system of flushing the goaf could not be applied to mining the Thick coal-seam of South Staffordshire. The chief reasons were that the seam was not

* "Water-packing of Seams," by Messrs. K. Müller and — Hussmann, *Trans. Inst. M.E.*, 1904, vol. xxvii., page 722; and "A Method of Packing Excavations in Coal-seams by means of Water," by Mr. E. O. Forster Brown, *ibid.*, 1904, vol. xxviii., page 325.

likely to be worked to the dip, for the sake of putting in water, and also that the Thick coal-seam was often worked three, four or five times over. The trouble at Hamstead colliery was that the fires were not in the stalls or goaf, but on the main roads. The last big fire occurred in a solid gate-road. It appeared to have commenced in the crevices of the coal-seam, and, in a very short time, a great mass of the road was ablaze and had to be dammed off. This occurred in solid coal, in a rib of the eye-pillar, not far from the bottom of the shaft, at the junction of two main roads.

Mr. F. A. Grayston observed that fires on the sides of the roads were not confined to the Thick coal-seam of South Staffordshire. In the Bench coal-seam of the Warwickshire coal-field, a soft coal somewhat similar to the Thick coal, fires were of frequent occurrence.

Mr. Henry Johnson said that some years ago he had the following experience, with a fire in a road in the Thick coal-seam, about 1,000 feet from the shafts, and at a depth of about 1,200 feet. The road, a side-road from a main intake-airway, had been dammed off at a point about 60 feet from the main road, and was unventilated except that the whole of the intake current of air, 60,000 cubic feet per minute, was passing the entrance to the disused road. The main road was driven with, and the side-road across, the cleat of the seam, so that breaks occurred somewhat parallel with the main road.

The first indication of fire was a very small quantity of smoke (about as much as a tobacco-pipe would give off) escaping from a break in the side-road, about 45 feet from the main road. A careful examination, with the aid of a pick, revealed the existence of a very extensive fire, ultimately resulting in laying idle that district of the mine, whilst the fire was being cut out, and substantial sand-casing and dams inserted: a task occupying labour equal to no less than 370 turns of work for one man. A knowledge of the existence of this large body of fire was prevented by the following circumstances:—The break in the seam in the side-road converged to the main intake-airway, some distance inbye from the side-road, and the products of spontaneous combustion, escaping from the break into the main road, were so completely diluted by the passing of 60,000 cubic feet of air, as to destroy all indications of fire-stink and active combus-

tion, until the presence of the small quantity of smoke, before referred to, led to its discovery. In consequence of this experience he (Mr. Johnson) made a rule to the following effect:—"The ventilating fan shall cease working during Sunday-morning examinations, when careful search must be made for fire-stink and fires in breaks in the seam, and particularly for breeding fires, above the roof-timbering of the roads." He submitted that it was practically impossible to locate a fire in its early stages in roads where they had a large ventilating current licking up and diluting all the products of spontaneous combustion as fast as they were made, and that was especially the case with fires in return-airways.

Mr. ALEXANDER SMITH said that probably many of the troubles at Hamstead colliery, due to crushing and fire in the main roads near the pit-bottom, were caused by the absence of brick arching. The late Mr. Henry Johnson was most insistent on the erection of arching when developing the Sandwell Park colliery (situated a short distance from the Hamstead colliery), and in consequence there had been comparatively few fires at that colliery.

Mr. ARTHUR SOPWITH said that he had had experience of thick coal-mining in Bohemia. There was not much trouble from fires in the gob, but there were many fires in the solid coal. This coal contained a high percentage of water (20 to 25), somewhat similar to the South Staffordshire Thick coal-seam, which contained a high percentage of moisture. On exposure to the air, the coal was dried, and fissures were formed in that way, and also through pressure. Along the fissure, a small current of air passed in and out, a small offshoot from the main ventilating current, causing a further drying of the coal and creating more fissures, and so the process went on. The air passing along the fissures was not sufficient to cool them, heat was generated by the absorption of oxygen, and increment upon increment of heat was added, until the temperature was sufficient to fire the coal spontaneously; and then it was necessary to drive a little heading to pick out the fire. Fires had been discovered in the mine-roads in Austria, after the pit had been standing for two or three months.

The conditions producing fires in the gob were analogous: They often originated where a prop had been left, the air

trickling into the space at the post, when conditions were set up exactly similar to the other case, the coal heating and ultimately taking fire.

Mr. W. N. Atkinson said he quite confirmed what Mr. Sopwith had said as to leakages of air causing gob-fires. His practice in the examination of places where gob-fires had broken out was to look out for places where such air-currents might have passed through; the evidence in most cases pointed clearly to such air-currents having existed; and it was beyond doubt that they were a cause of gob-fires.

Mr. Laurence Holland, replying to this and the previous discussion, said it was true that a certain amount of cool air leaked into the return-airway through bolt-holes in the coal, and it was necessary to allow a small quantity of air to pass through them in order to keep the roads cool. If this were not done, the heat developed through the oxidation of the coal would accumulate, and cause fires in the breaks of the coal. This, however, only accounted for a small decrease in temperature; for it was 80° Fahr. beyond the last connecting road between the intake and return-airways, through which it was possible for any leakage to occur. The temperature of the coal at this point, ascertained in a bore-hole, was 72° Fahr. About 1,200 feet nearer to the upcast shaft, where the airway rises up to the Brooch coal-seam (lying 120 feet above the Thick coal-seam), the temperature of the air fell to 74½° Fahr., and the temperature of the rock was 69° Fahr. taken in a bore-hole. In the next 1,200 feet, the air was cooled down to 70½° Fahr., thus showing a decrease of 9½° Fahr. in the temperature in a distance of 2,400 feet, and it could only be accounted for by the cooling action of the strata. From that point to the upcast shaft-bottom, the conditions had been altered since the observations given in the paper were recorded, so that further readings could not be taken to compare with those given at the pit-bottom. It might be remarked that the temperature would be slightly reduced by water running down the sides of the shafts, and also by the pit not being at work.

Since liquid air had been brought forward as a suggested means for cooling the mine, he (Mr. Holland) had made investigations with a view to making use of it. Its properties were unique, and if it could be produced at a reasonable price it would

undoubtedly prove a boon to mining engineers working the Thick coal-seam. When a side-of-work was being brought back, the temperature gradually rose to about 90° Fahr., and a fire soon followed; sometimes resulting in the loss of a considerable amount of the top coal which had been undergone and was ready for dropping and loading up. If the temperature could be maintained at 80° Fahr., the top coal (which is generally the best part of the seam) would be saved, thus giving a greater tonnage for the same cost of heading in cutting up the work. Liquid air evaporated at minus 295° to 313° Fahr. The greater the atmospheric pressure, the higher the boiling point would be, so that if it evaporated at minus 295° Fahr., 1 cubic foot of air from the liquid would reduce about 100 cubic feet of air in the mine from 86° to 80° Fahr. Now, if 1,000 cubic feet of air per minute were allowed for a panel or side-of-work, it would require 10 cubic feet of the evaporated air per minute to maintain the temperature at 80° Fahr. The lowest price quoted for liquid air was 20s. per litre, and a litre evaporated into about 24 cubic feet of air, so that the cost of reducing the temperature, as above described, would be about 8s. per minute. Liquid air cannot be kept in a closed vessel, as it is made under a pressure of about 800 atmospheres at a temperature many degrees below freezing point, so that it cannot be stored.

It had been suggested that driving out to the boundary under the coal-seam avoided coal-fires in the roads, but he (Mr. Holland) would prefer to go further than that, and work out a coal-seam below the Thick coal-seam, thus having the double advantage of getting rid of the coal-fires in the roads, and also of setting the Thick coal-seam and reducing its tension. With regard to the suggested method of filling the openings with débris and sand, his (Mr. Holland's) experience of both rock and sand was that they retained the heat; and where sand-dams were put in, after some time, the temperature of the sand rose to 120° and 130° Fahr.: so fresh dams had been put in, or the coal would have fired on the outer side of the dam. The distance between the intake and return-roads did not greatly affect the fires on the sides of the roads, as they often occurred on the far side of the intake-road from the return-airway. With regard to the crushing of the pillars between the intake and return-airways, it was found that the coal stood best when these roads were driven at least 200 feet apart.

THE MINING INSTITUTE OF SCOTLAND.

GENERAL MEETING,
HELD IN THE CO-OPERATIVE HALL, COWDENBEATH,
JUNE 17TH, 1905.

DR. ROBERT THOMAS MOORE, PRESIDENT, IN THE CHAIR.

The members visited the Mary pit, Lochore, the Aitken pit, Kelty, and Cowdenbeath No. 10 pit.

The PRESIDENT (Dr. Moore) moved a hearty vote of thanks to the directors and officials of the Fife Coal Company, Limited, and it was cordially approved.

The minutes of the last General Meeting were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. JAMES BRYSON, Pumpherston Oil Works, Mid Calder.
Mr. JOHN DONALD, Orbiston Collieries, Bellshill.
Mr. JAMES LAWSON, Home Farm Colliery, Hamilton.
Mr. WILLIAM M. MARTIN, Ellangowan, St. John's Street, Coatbridge.
Mr. H. P. MEARES, 34, Ancaster Drive, Anniesland.
Mr. ALEXANDER ROBERTSON, Redding Collieries, Polmont Station.
Mr. RICHARD ROBERTSON, 7, East Cottages, Bowhill, Cardenden.

ASSOCIATE MEMBER—

Mr. R. M. BURLAND, 9, Watson Terrace, Shettleston.

ASSOCIATE—

Mr. ANDREW K. McCOSH, JUN., Gartsherrie Iron Works, Coatbridge.

DISCUSSION OF MR. E. O. FORSTER BROWN'S "NOTES ON THE APPLICATION OF ELECTRIC POWER AT MINES IN GERMANY."*

Mr. E. O. Forster Brown, replying to the discussion, wrote that the chief difficulty with gas-engines, as Mr. Balfour had remarked, appeared to be in getting the sufficiently cleaned gas into the cylinders to avoid continual repairs and overhauling. His (Mr. Brown's) remarks on the subject only referred to gas from coke-ovens; and, no doubt, the intermittent supply of gas from a small plant was also an important consideration.

A frequency of 50 periods per second was commonly used for alternating current and was sufficiently high to avoid the necessity of generating continuous current at a distance from the central station for lighting purposes.

The high-speed reciprocating pumps, referred to in his paper, were twin double-acting piston-pumps, driven direct by three-phase slip-ring motors at 5,000 volts and 150 revolutions per minute: the motors having 40 poles and a periodicity of 50. At the Saar-Mosel collieries, four pumps of this description had been erected, two in duplicate of 385 kilowatts each, pumping water from the bottom of a shaft 1,638 feet deep; and two in duplicate of 385 kilowatts at the bottom of a shaft, 1,146 feet deep. It was originally intended to erect two more pumps of the same description at the bottom of another shaft, 1,650 feet deep; but, since reading the paper, he (Mr. Brown) had been informed that, owing to the high cost of repairs experienced with the pumps of this type at present working, it had been decided to adopt high-speed centrifugal pumps, 56 inches in diameter, driven by motors of 225 kilowatts: the first cost of a plant of this description would also be much less.

No doubt, where sand as well as water had to be pumped, the lining of the centrifugal sinking-pump might not last for more than two years, but it was questionable whether any other type of pump would last as long. In Silesia, where the coal-pillars were being replaced by sand sluiced underground with water, centrifugal pumps were preferably employed for repumping the water to the surface, as it still contained a small quantity of sand, and, under these conditions, this type of pump gave the best results.

* *Trans. Inst. M.E.*, 1905, vol. xxix., pages 40 and 123.

For three-phase current, three-cored cables were generally used, and were armoured throughout.

Apart from questions of safety and convenience, the advantage of using electrical power at collieries altogether depends upon the value of the coal burnt under the boilers; where boiler-coal reaches a certain value—other conditions being equal—the initial expense of putting in electrical plant and the loss of efficiency in transforming one form of power to another is more than made up for by the efficient transmission and saving of heat-radiation during intermittent working. Apparently in Scotland, boiler-coal is often unsaleable and the conditions would only be applicable in extreme cases, or where the waste-gas from coke-ovens could be directly converted into electricity by means of gas-engines.

The following paper on "The Coal-fields of Cape Colony," by Mr. Archibald Russell, was taken as read:—

THE COAL-FIELDS OF CAPE COLONY.

By ARCHIBALD RUSSELL.

INTRODUCTION.

Only a small area of the vast African continent has been explored for minerals, and the prospecting and mining hitherto carried on, have been principally for gold and diamonds. It is in connection with these products that the mineral-wealth of Africa is associated, a greater glamour being thrown over their discovery and working than over that of coal.

In the Sudan, indications of coal-bearing strata have been observed, whilst the writer had brought to his notice, two years ago, the existence of very likely-looking carboniferous indications on the great caravan-route between Kumasi, in Ashanti, and Timbuctoo, on the Niger river, *via* Kintampo, Banda and the Northern territories. Recently, thin seams of coal have been discovered in one of the tributaries of the Lualaba river, in the Congo Free State, about 10 degrees south of the Equator; and this might be the precursor of a large coal-field, which would be of enormous value in the opening up of Central Africa by the railway now being constructed from Lobito Bay, on the West Coast, to the interior.

In South Africa, coal is found in numerous localities, from Tete on the river Zambesi, where Dr. Livingstone discovered a coal-seam in 1856 (16 degrees south of the Equator) to near Queenstown in Cape Colony (32 degrees south of the Equator). Although the deposits hitherto discovered are detached, and no great area of country is coal-bearing in one region, yet they are, taken together, of considerable area, and contain an enormous quantity of coal in seams of workable thickness and quality. Their development has played no small part in the opening-up of the resources of South Africa during the last quarter of a century; and the position which Johannesburg occupies as the

premier gold-producing area in the world is to a great extent due to the existence of immense coal-resources in the neighbourhood (Fig. 1, Plate VII.).

The Transvaal and Natal coal-fields have already been ably described in the *Transactions* of the Institution. Rhodesia, although shewing promise of a prosperous coal-industry, has not been thoroughly prospected for coal-seams so far; and very little information is available concerning the same. It is the intention of the writer to contribute a brief account of the coal-fields and geology of Cape Colony.

Geological Position of the South African Coal-fields.

The geological horizon of the South African coal-fields has not yet been fixed, but they are generally assumed to be of Triassic age.

In the Eastern Transvaal coal-field (Springs, Ermelo and Middelburg districts), the strata are composed of bedded sandstones and shales, with fossil-plant remains of *Glossopteris*, *Calamites* and *Sigillaria*.

In the South Rand coal-field, the Coal-measures rest unconformably on the older metamorphic rocks, and at their base, is a breccia, which is supposed to be the Dwyka Conglomerate. *Favularia* and Lepidodendroids have been discovered in this district.

In the Vaal River coal-field (Vereeniging, Heilbron, etc.), probably a continuation of the South Rand coal-field, the Coal-measures rest directly on the Dwyka Conglomerate, and fossil remains of *Glossopteris* have been found underneath the coal-seam.

In Natal, the Coal-measures are conformable with, and lie immediately above, the Beaufort Beds, with Ecca Beds underlain by the Dwyka Conglomerate below, thus shewing that they occupy the same geological position as in Cape Colony.

With regard to the various detached coal-fields found in the Transvaal, at Springs, they abruptly abut against the older metamorphic rocks, in which the auriferous banket-reefs of the Witwatersrand are found; at Cypherfontein, south-west of Johannesburg, a small coal-field is underlain by dolomite; and at Buffelsdoorn, near Klerksdorp, where the overlying rock is a flinty quartzite, and that underlying gold-bearing, the Coal-

measures seem to have been formed by the filling in of large depressions or basins in the older strata. It is interesting to note that in the White Reef, worked extensively at the Buffelsdoorn gold-mines, a few years ago, thin threads of anthracite up to ¼ inch thick were found; and their presence in the reef was a sign that it was of more than average richness.

It would seem, from present available knowledge, that the coal-bearing strata in South Africa were formed at one period; but that in various localities, certain beds were much thicker than in others, or were entirely wanting. This is supposed by some geologists to be the case with the Beaufort and Ecca Beds in the Southern Transvaal. The investigations of geologists, however, who are greatly assisted in their labours by the numerous diamond bore-holes at present being sunk all over the country, should at no distant date afford conclusive evidence on this subject.

The heights above sea-level, at which coal-seams are found in South Africa, are as follows:--Bechuanaland, Palapye, 3,000 feet. Cape Colony: East Griqualand, 4,400 feet; Indwe, 4,500 feet; and Stormberg, 5,300 feet. Congo Free State, Lualaba, 3,100 feet. Natal: Dundee, 4,200 feet; Elandslaagte, 4,000; and Laing's Nek, 5,000 feet. Orange River Colony, Vierfontein, 4,300 feet. Rhodesia, Tuli, 1,750 feet; and Wankie, 2,000 feet. Transvaal: Middelburg, 5,000 feet; Springs, 5,300 feet; and Viljoen's Drift, Vaal river, 4,700 feet.

Cape Colony.

The coal-fields of Cape Colony are situated in the northern portion of the Eastern Province and Native Territories; and at the foot of the southern slope of the Drakensberg or Quathlamba mountains, which form the principal watershed of South Africa, extending as they do from the Great Karroo, to Swaziland (Fig. 2, Plate VII.).

This coal-bearing area extends on the west from Wondeboomspruit, about 15 miles west of Molteno township, through Albert and Wodehouse electoral divisions, Northern Tembuland and Griqualand East to the Natal border, a distance of 250 miles. The southern limit is approximately known, but the northern boundary has not yet been determined, and it is very probable that coal-seams of economic value may exist at Aliwal North,

Herschel and in Basutoland. Prospecting for minerals, however, in Basutoland has hitherto been discouraged by the Government of Cape Colony and the native chiefs, who are well aware of the changes that would ensue if mining operations were allowed in their territories.

The writer purposes to divide his description of this enormous tract of country into three districts, as follows:—(I.) The Stormberg, Molteno or Western coal-field; (II.) the Indwe or Central coal-field; and (III.) the Tembuland or Eastern coal-field.

Geology.

The classification adopted by the Geological Commission of Cape Colony for the strata in that Colony is as follows:—

Superficial Deposits:	... ...	**Sands, gravels and estuarine deposits.**
Karroo System:	**Stormberg Series:**	**Volcanic rocks.**
		Cave Sandstone.
		Red Beds.
		Molteno Beds.
	Beaufort Series:	**Kentani and Idutya Beds in Transkei.**
	Ecca Series:	**Umzimkaba Beds in Transkei.**
	Dwyka Conglomerate Series.	
Cape System:	**Witteberg Series.**	
	Bokkeveld Series.	
	Table Mountain Series.	
Pre-Cape System.		

In the eastern portion of Cape Colony, all the strata belong to the two first-named systems (with the exception of a small area near St. John's, in Pondoland), but only a small area has so far been examined by the field-staff of the Geological Commission of Cape Colony.

The following is a brief résumé of the principal geological features:

(1) *Table Mountain Series.*—At the mouth of the Umzimvubu, a large river rising in the Drakensberg and flowing in a south-easterly direction, an inlier of coarse-grained sandstone is found at the wellknown Gates of St. John, where cliffs covered with dense forest and verdant vegetation rise almost perpen-

dicularly from the river-edge to a height of over 1,000 feet, and form one of the bestknown landmarks of the South African coast. This is a small patch of the Table Mountain Series, and a larger area is found about 20 miles in a north-easterly direction, where high cliffs of a reddish colour are very noticeable.

There is a huge waterfall in this district, in a small river which falls over 500 feet in one sheer drop. It was formerly used as a place of execution for victims of Pondo chiefs, who persuaded them to walk over blindfolded.

(2) *Dwyka Conglomerate Series.*—The Dwyka Conglomerate can be seen near St. John's village in Pondoland; also inland for a short distance up the valley of the Umgasi river; and it extends in a north-easterly direction into Natal.

The Dwyka Conglomerate is formed of an indurated boulder-clay containing boulders of slate, quartz and granite, and shewing ice-scratchings. The greater portion of this deposit, however, is composed of bedded dark-coloured shales, and their position with regard to the Conglomerate makes this series a very good datum for the determination of the relative position of other strata.

The Conglomerate is found immediately below the Coal-measures in the north of the Orange River Colony; but, so far, no coal-seams have been found in this locality, although boring operations have been unsuccessfully carried on, near Durban, in search of coal.

(3) *Ecca Series.*—The Ecca Series or Umzinkaba Beds, is well-developed in the south-eastern Transkei. The most commonly occurring beds are blue and purple shales, with intervening seams of buff and whitish sandstones (occasionally false-bedded), the former decomposing into a fertile dark-coloured soil. The strata, in the beautiful and deep valleys of Pondoland, belong principally to the Ecca Series, also those in the south-western Transkei, towards the mouth of the Kei river.

Intrusive dolerite is very much in evidence. A notable example of dolerite-intrusion is seen in western Pondoland, at the famous mountain, Umlengani, which rises for hundreds of feet almost perpendicular on all sides: the inaccessible top is an intrusive bedded dolerite.

In a road-cutting, hereabouts, there are over 400 feet of beds, principally reddish shales, which were measured by the writer.

To the north-west, towards Umtata, 2,300 feet above sea-level, the sandstones seem to be more in evidence, but the country is of a gently undulating character, and the strata are not prominently exposed.

The wellknown falls, 80 feet high, on the Umtata river, are caused by a dolerite-dyke which crosses the river-bed.

No coal-seams have been found in this division, although dark arenaceous shales with fossil fern-impressions have been found. The natives assert that coal exists in some valleys, but the dense bush is a great hindrance to exploratory work.

Calamites and *Glossopteris* have been found in the Ecca Series in the Western Province of the Cape Colony in great abundance.

(4) *Beaufort Series.*—The Beaufort Series lies conformably upon the Ecca Beds, to which they bear a strong resemblance. The beds extend from Cathcart to the north-east, through the Transkei, to Umtata, Kokstad and Natal. They extend for a considerable distance to the south-west *via* King William's Town and Cookhouse to the Great Karroo. The rocks forming this series are principally red and purple shales and mudstones, with numerous sandstone-beds, some of which are of great thickness.

The total thickness of the Beaufort Beds is not exactly known, but as they are recognized not far from the mouth of the Kei river (north-east of East London) and their topmost beds can be seen at Indwe and Cala, it cannot be less than 3,500 or 4,000 feet.

A good section of the upper portion of the Beaufort Series is exposed in the road from Kei bridge, at St. Marks, up through Komati Poort to the watershed of Incuncusa, a distance of about 12 miles, in which over 2,000 feet of strata can be measured.

Owing to the weathering of the comparatively soft shales, large blocks of sandstone have become undermined and toppled over into the valleys, and it is a common occurrence to see immense detached boulders standing in the midst of fertile cultivated lands.

A somewhat similar section of strata can be seen in the Quotenyi Pass, from Engcobo to Sandangeni, where over 1,200 feet of Beaufort Beds are overlain by the Molteno Beds.

Table I. comprizes a section of the middle portion of the Beaufort Beds, measured downwards by the writer, in a native footpath up the eastern slope of the Xwenwene mountains, forming the watershed between the Emjanyana leper-settlement and Egcosa mission-station, south-east of Engcobo.

TABLE I.—SECTION OF THE BEAUFORT BEDS ON XWENWENE MOUNTAINS.

No.	Description of Strata.	Thickness of Strata. Ft.	No.	Description of Strata.	Thickness of Strata. Ft.
1	Sandstone	30	11	Red shales	95
2	Dolerite-sheet	40	12	Purple and red shales, with sandstone-beds	140
3	Light-red shales	20	13	Sandstone, very prominent ...	60
4	Fine-grained sandstone ...	25	14	Red and purple shales	120
5	Purple shales, with thin sandstone-beds	85	15	Yellowish sandstone	35
6	Fine-grained sandstone	120	16	Red shale	70
7	Red and purple shales	180	17	Light-coloured shale	40
8	Light-coloured shales	60	18	Sandstone in the river-bed ...	30
9	Dolerite-sheet	35			
10	Sandstone	70		Total height of section ...	1,255

Fossil fern-markings are very common, and distinct ripple-marks are seen in the sandstone. The writer, in 1898, found thin seams of dark carbonaceous shale (arenaceous in character) in the upper beds in the valleys to the west of Tsojana Kop. The natives had mined the shale to a small extent, but they found that it was almost useless as fuel. In the Western Province, however, coal-deposits have been found in this series.

(5) *Molteno Beds.*—The Molteno Series rests conformably on the Beaufort Beds, and the line of demarcation is very noticeable, the lower series being distinctly of a reddish colour. This series contains the only workable coal-seams hitherto found in Cape Colony; and averages about 1,000 to 1,200 feet in thickness, although in the Stormberg district the rocks are nearer 2,000 feet thick.

An excellent section of the strata of the Molteno Beds can be observed on the Indwe railway, in the heavy incline from Doorn river, near Indwe station, up to the top of Umhlanga valley. Another good section is seen in the road-cutting leading out of Cala, towards Elliot, with the top of the Beaufort Beds cropping out near Cala bridge.

Table II. contains a section of the strata, as measured by the writer, in one of the valleys between Cala and Sifonondili; and approximately it lies immediately above the section of strata contained in Table I.

TABLE II.—SECTION OF THE MOLTENO BEDS BETWEEN CALA AND SIFONONDILI.

No.	Description of Strata.	Thickness of Strata. Ft.	No.	Description of Strata.	Thickness of Strata. Ft.
1	Sandstone, indurated	140	11	Fine-grained sandstone ...	70
2	Sandstone, coarse-grained ...	70	12	Fine-grained sandstone, with shale-laminations	40
3	Dark shale. Position of Cala *Upper Coal-seam*	5	13	Coarse-grained sandstone ...	55
4	Sandstone and light-coloured shales	30	14	Pale-coloured sandstone and shale	90
5	White laminated sandstone ...	20	15	Dark-grey sandstone	70
6	Yellow shale	2	16	Fine sandstone	160
7	White sandstone	40	17	Red shales, forming the top of the Karroo Beds	...
8	Yellow sandstone, with large pebbles	20			
9	Coarse-grey sandstone	120		Total height of section ...	934
10	COAL and shale. Cala *Lower Coal-seam*	2			

The greater thickness of the strata is composed of hard felspathic sandstones, with occasional beds of light-coloured shale; the upper portion consists principally of coarse-grained sandstone, which forms prominent *krantzes* or ledges. One bed, in particular, known as the Indwe sandstone, which has apparently been affected by sheet-dolerite, is very prominent, and can be traced for many miles in the valleys and deep kloofs eroded by the creeks and streams in the watersheds of the Indwe and Tsomo rivers.

The coal-seams are found in the lower portion of the Molteno Series, and although, generally, more than one distinct coal-seam exists in the same locality, yet almost without exception, only one coal-seam is of workable thickness and quality (Table VI.).

The coal-seams appear to have been formed *in situ*, but the large percentage of incombustible matter occurring between the different bands of coal, and intimately associated with the coal itself, tends to prove that the vegetation composing the coal-seams flourished and decayed in muddy and slow-running water. The variable nature of the coal-seam in this coal-field would incline one towards the theory that the vegetation grew in a series of lakes or lagoons, more or less connected, rather than in one large basin, and the "wash-outs," or "wants," or layers of sandstone, which often replace part of, or the whole of a seam for a considerable area, indicate where subsequent rivers had cut their way through the newly-formed coal-beds.

The occurrence of so many bands of shale can be explained by the supposition, that large quantities of silt or mud were

washed into the detached lakes, at various periods during the growth of the vegetation.

The occurrence of the alternate layers of coal and shale recalls the strata worked for clayband-ironstone at Braidwood and Knightswood in Scotland; whilst the writer noticed a great similarity between the "wants" in the coal-seams of Cape Colony and those found in the Slatyband ironstone worked in Linlithgowshire, and in the Blackband ironstone of the Western Fife coal-field.

The roof and pavement of the coal-seams are of coarse-grained sandstone, but more or less carbonaceous shale or fire-clay (as at Cyphergat) is present in the roof, and thin bands or ribbons of pure coal are found in the sandstone immediately above the coal.

Fire-clay or under-clay is not as a rule found in the pavement, but it is generally present in the coal-seams of the Glen Grey district, near Indwe.

The total thickness of shale and coal found in these deposits varies from a few inches to about 12 feet (the thickness found where the first coal-seam was discovered, at Indwe), but the thickness of workable coal in one section never exceeds 3½ feet; and, as a rule, no seam containing under 1½ feet of coal is workable at a profit.

The lower strata of the Molteno Beds are composed of fine-grained sandstones with occasional thin shale seams. Thin beds of conglomerate or "banket" have also been found in this section; one bed occurs about 260 feet below the Indwe coal-seam, and is 2 feet thick. A second banket-bed, locally known as the "oyster-bed," is found a few feet above the Guba or Macubeni coal-seam: it is composed of a cemented mixture of small pebbles of quartz and ironstone-nodules, and is a reliable index to the position of the underlying coal-seam, the outcrop being generally covered with boulders, surface-soil and debris. A similar conglomerate was noticed by the writer to the west of Molteno township, but its position as regards the horizon of the coal-seam could not be ascertained.

The junction of the Molteno Beds with the Beaufort Beds is easily recognized by the change in the strata from light-coloured fine-grained sandstone to red and purple shales. The top of the Beaufort Beds is 400 feet below the coal-seam at Indwe; near

Cyphergat, it was found to be 340 feet, while in the Eastern Cala district it is over 500 feet below.

Numerous fossil remains have been obtained from the Molteno Beds, especially from the coal-beds and the strata immediately superimposed on them. *Calamites* and *Lepidodendron* have been found in the Glen Grey and Engcobo districts, and impressions of fern-like plants, similar to *Neuropteris* have been noticed by the writer in the sandstone above the coal-seams; also other unrecognizable fossils have been found in the shales above the coal-seams in the Stormberg coal-field. In the underlying fire-clay *Stigmaria* has been recognized, whilst fossil-trees, standing in a vertical position, have been discovered in the Molteno district.

Nodules of iron-ore are often found in the sandstone-beds above the coal-seams, dark red or purple in colour, but their comparatively small quantity renders them of no commercial value. One sample found by the writer, not far from Lady Frere, contained 60 per cent. of iron. It is believed that from these ironstone-nodules, the semi-savage Bushmen, who inhabited the north-eastern part of Cape Colony (the last survivor died comparatively recently in the Drakensberg mountains on the Basuto-land border) obtained pigments for colouring the crude drawings of men and animals, which are found on sandstone-cliffs in various localities: Bushman's Hoek, Dordrecht Kloof and Rebels Kloof, near Cala, affording good examples.

(6) *Red Beds.*—This is the name assigned by Mr. E. J. Dunn to the red, purple and pale-yellow shales interstratified with sandstones which rest unconformably on the Molteno Beds. The sandstones are much finer grained than in the Molteno Beds, and are not dissimilar to those of the Beaufort Beds, but the position of the Indwe sandstone is a good index to the difference in geological position. The thickness of strata is variable, being only 200 to 300 feet thick, near Matatiele, and 600 feet at Sieur Hoek, in the Embokotwa (near Indwe), about 100 miles to the south-west.

It is not easy to demarcate the upper and lower limits of the Red Beds, except that the sandstones and shales of the underlying Molteno Beds are of a buff and whitish-grey colour, while the overlying Cave Sandstone contains comparatively few shales.

Good sections of this series are seen in the foot-path leading from Onvernacht farm to the Waschbank; at Barkly Pass, where they are 1,200 feet thick; and in the Kraai river in Barkly East district.

The town of Dordrecht is situated in this series, and in 1878, a bore-hole was sunk by the Government in search of coal, and passed through the strata recorded in Table III. The bore-hole was discontinued at the depth of 164½ feet, owing to the sudden departure of native labourers to assist Gungubele, a Tambookie chief, in a rebellion in the native territories, but the writer believes that it is in strata lying from 400 or 500 feet above the horizon of the coal-seam.

TABLE III.—SECTION OF STRATA BORED THROUGH AT DORDRECHT.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Surface-soil and clay	9	0	9	0	4	White sandstone ...	17	0	81	0
2	Sandstone and basalt-boulders	20	0	29	0	5	Bluish-grey rock ...	9	6	90	6
						6	White sandstone ...	41	6	132	0
3	Blue shale	35	0	64	0	7	Bluish-grey rock ..	32	6	164	6

(7) *Cave Sandstone.*—This name is given to the series of coarse-grained grey and buff sandstones resting conformably on the Red Beds. The thickness is very variable, being unimportant at Penhoek, near Sterkstroom, and gradually increasing in thickness to the westward, until near Barkly Pass, the strata are about 800 feet thick. On the Waschbank mountains, to the north of Indwe, Mr. E. J. Dunn gives the thickness as 300 feet, whilst at Matatiele the thickness varies from 100 to 400 feet.

As may be inferred from the name, the erosion of their softer layers in many instances, has been the means of the formation of caves, which were formerly occupied by the aboriginal natives, and now are occasionally utilized to shelter flocks in severe weather.

The sandstones frequently assume fantastic forms, on account of the influence of the weather, and gigantic monoliths are occasionally found perched on the top of cliffs or lying in the midst of an extensive plain. One splendid example is seen on the northern boundary of Koorn Hoek farm, near Indwe; whilst at Gatberg, 10 miles east of Elliot, a passage or tunnel exists through the mountain-side.

Over its whole area, the Cave Sandstone has been much disturbed by volcanic eruptions, and no coal-seams have been found.

In Quokana valley, on the northern and precipitous side of Xalanga Peak, distinct ripple-markings in the sandstone and fossil-impressions of ferns were noticed by the writer.

(8) *Volcanic Rocks.*—The igneous rocks have played a considerable part in the geological history of Cape Colony, and numerous examples of extinct volcanoes and eruptive lava have been found. One mixed mass of volcanic tuff or ash, discovered near Barkly Pass, is very similar to that found in central Scotland; and a very distinct example of the same can be seen at Greenhead cutting in the Wishaw and Newmains branch line. The beds of volcanic ash are often found interbedded in the Cave Sandstones in the Maclear and Matatiele districts.

Huge masses of dolerite have been erupted through the Ecca, Beaufort and Molteno Beds: and horizontal sheets, covering a great area and varying in thickness from hundreds of feet to a few inches, can be observed in the hill-sides and have also been proved by bore-holes.

In the Molteno district, there is not so much dolerite compared with the district extending from Dordrecht eastward, especially in the Glen Grey and Cala districts.

One sheet in the Glen Grey district has been proved to be about 300 feet thick; and it is extremely probable that a sheet, or various sheets at one time covered the whole of the Indwe coal-field at a distance of about 250 feet above the thick coal-seam, imparting to the coal its semi-bituminous character, and indurating the sandstones, which came into contact with the molten dolerite.

Where the intrusive dolerite-dykes have come into actual contact with the coal-seams, the latter have become of a hard, stony nature, and though the outside part of the dolerite becomes soft and of a greyish colour, the internal core is of a very solid and homogeneous structure, with little or no defined planes, and difficult to drill and blast. Occasionally, such dykes are found in the coal and shale-seams and interbedded with them, or have sent out small branches into the adjoining strata. Fig. 4 (Plate VII.) shews an occurrence of the latter nature ob-

served in the Beaufort Beds in the Clarkebury district of the Transkei.

The dolerite-dykes are generally found in an almost perpendicular position, but Fig. 8 (Plate VIII.) shews one example, where the intrusive mass is found lying at an angle of 45 degrees, as proved by its outcrop on the cliffs about 80 feet above the coal-seam.

The hard resisting dolerite (which is very similar to the whinstone found in the Shotts district of Lanarkshire) has been the means of protecting the underlying strata from denudation and thus saving valuable areas of coal-bearing strata.

Although of a dark bluish or greenish colour, the dolerite weathers into spheroidal boulders, with a reddish tinge on the exterior (from the contained small percentage of iron); and the soil found in districts much affected by it is of a deep chocolate or black colour, and capable of bearing magnificent crops of maize, year after year, without artificial enrichment.

As intrusive dolerite, whinstone or trap is met with in many of our British coal-fields, it would be very interesting and of great value, could data be collected and tabulated, regarding the influence which those intrusive rocks, both as sheets and dykes, have on the adjacent coal-seams.

In the north-east of Lanarkshire and Stirlingshire coal-fields, dolerite occurs; but, so far as the writer is aware, the vertical dykes have comparatively little effect on the coal, even when within a few feet of a thick intrusion, except that the coal is very friable. The thick whinstone-sheets, which are found 200 feet thick in places, have imparted to the coal-seams of Slamannan and Kilsyth a semi-bituminous character.

Mr. W. T. Heslop has described the effect of dolerite on the Natal coal-seams.*

At the New Campbell collieries in the Dundee district, an occurrence of a dolerite-dyke 1,200 feet thick is described. At 100 feet from the dyke, the coal contained 4 per cent. of volatile matter; at 1,200 feet, 15 per cent.; and at 1,400 feet, 19 per cent.; so that the coal seemed to have been affected for a distance a little more than the thickness of the intrusive mass.

At the South African collieries, in the same coal-field, the dolerite exists as a horizontal sheet, columnar in structure, 153 feet thick, where pierced by the shaft. The coal-seam, 86 feet

* *Trans. Inst. M.E.*, 1900, vol. xviii., page 416.

below the dolerite, contained only 8·6 per cent. of volatile matter, as against 18 per cent., the average content in the district.

In Cape Colony, the writer observed that the thickness of the coal was affected on either side of a vertical dolerite-intrusion and the following are some examples:—A dyke, 5 feet thick, affected the coal on either side to a distance of 20 feet; 8 feet, 35 feet; 12 feet, 50 feet; 18 feet, 50 feet; 30 feet, 80 feet; and 30 feet, 200 feet.

It would seem as if the area of coal affected did not vary as the thickness of dyke, but was to a great extent dependent on the nature of the dolerite, some intrusions being of a soft, white chalky nature (the ferric oxide having become changed into ferrous oxide) whilst others of greater thickness are hard and ring with a metallic sound when struck with a bar; (hence the Dutch name *yser klip* or ironstone).

Often the coal assumes a whitish appearance close to dykes, and is very hard and of high specific gravity.

The coal-seams in South Africa are affected by comparatively small dykes, probably owing to the presence of a high percentage of incombustible matter, from 10 per cent. to 30 per cent., while in Great Britain the seams contain, as a rule, only 1 to 4 per cent.

I.—Stormberg or Western Coal-field.

The nearest coal-fields to the sea-coast in Cape Colony are those situated close to the township of Sterkstroom, 190 miles from East London on the Eastern Railway of the Colony, and the point of junction of the Indwe-Natal Border Railway (Fig. 2, Plate VII.).

Three distinct coal-seams have been found in the neighbourhood, but there is only one of workable thickness, containing 32 inches of coal with interbedded shale-seams. The coal is anthracitic in character, very high in ash, and of very little value. About 2 miles north of the village, a drift, close to the east of the railway, was put in to test a thin seam cropping out under a small isolated sandstone-plateau, but with unsatisfactory results.

In the kopjes to the south of Sterkstroom, not far from Putters Kraal station, thin seams of coal have been discovered,

but are of no value, being greatly affected by dolerite. In fact, all the coal-seams about this district are more or less disturbed by the same agency. The following is an analysis of the coal of a seam, 2 feet 8 inches thick, tested by the Government chemist in 1891:—Coke, 51·38 per cent.; ash, 30·36 per cent.; volatile matter, 18·26 per cent.; and moisture, 0·66 per cent. It had a specific gravity of 1·47.

Comparatively little real mining has been done in this district, although, at various times, spasmodic efforts have been made to establish collieries on a small scale by local companies.

The top of the Beaufort Beds is found about 200 feet below the position of the lowest coal-seam in the Sterkstroom district.

A few miles north of Sterkstroom, the railway commences the steep ascent up the Bushman's Hoek (the vertical rise being over 1,000 feet in about 10 miles), and in this thickness no fewer than five coal-seams have been described by Mr. F. W. North, as being present,* and he gives the following section of the strata (Table IV.)

TABLE IV.—SECTION OF STRATA AT BUSHMAN'S HOEK.

No.	Description of Strata.	Ft.	In.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Coarse sandstone ...			...		...	
	No. 1 Coal-seam—						
2	Bat ...	0	2				
3	COAL ...	0	3				
4	Shale ...	0	4				
5	COAL ...	0	9				
6	Bat ...	0	2				
7	COAL ...	0	1				
8	Shale ...	0	2				
9	COAL ...	0	5				
				2	4	2	4
10	Sandstone, and occasional thin shales			75	0	77	4
11	Shale			2	0	79	4
	No. 2 Coal-seam—						
12	COAL ...	0	4				
13	Shale ...	0	3				
14	COAL ...	0	9				
15	Shale ...	0	3				
16	COAL ...	0	2				
17	Shale ..	0	2				
18	COAL, shaly ...	0	9				
				2	8	82	0
19	Strata			25	0	107	0
20	Shale			3	0	110	0
	No. 3 Coal-seam—						
21	COAL ...	0	3				
22	Shale ...	0	8				
23	COAL ...	0	4				
24	Shale ...	0	3				
25	COAL ...	0	2				
26	Shale ..	0	5				
27	COAL ...	0	8				
				2	9	112	9
28	Shale			3	0	115	9
29	Strata			192	0	307	9
30	Sandstone			5	0	312	9
	No. 4 Coal-seam—						
31	COAL ...	0	2				
32	Shale	0	6				
33	COAL ...	0	3				
34	Shale ...	0	4				
35	COAL ...	0	6				
				1	9	314	6
36	Strata			197	0	511	6
37	Sandstone			3	0	514	6
	No. 5 Coal-seam—						
38	COAL ...	0	5				
39	Shale ...	0	6				
40	COAL ...	0	5				
41	Shale ...	0	5				
42	COAL ...	1	11				
				3	8	518	2

* *Colonial Mining Engineer's Report on the Coal-field of the Stormbergen*, by Mr. F. W. North, 1878.

A small area of the No. 5 coal-seam was mined about 30 years ago, but the working was unprofitable, principally owing to the high percentage of ash. It is not improbable that there is a large fault, with a downthrow to the south, existing between Bushman's Hoek and Sterkstroom, as the Beaufort Beds are found 500 feet lower in the Sterkstroom coal-field than in the Northern coal-field, a discrepancy which cannot altogether be accounted for by the inclination of the strata.

About 1½ miles east from Cyphergat station, on the higher plateau, a coal-seam was worked for about twelve years at the Fairview mines, and a branch-line afforded a connection with the main line of railway. Operations were, however, on a very limited scale, and the mine was closed a few years ago, principally owing to the prevalence of dolerite-dykes. The seam had the following section:—Roof: fire-clay and shale; seam: coal, 4 inches; shale, 3½ inches; coal, 6 inches; shale, 3 inches; coal, 3½ inches; shale, 4 inches; and coal, 13 inches.

Cyphergat is a small mining village, about 14 miles north of Sterkstroom, on the railway-line. Coal was first found here in 1859 (this being the first-recorded discovery in Cape Colony); and, since 1882, a local company has worked mines with more or less successful results.

The coal-seam is found at a shallow depth, and is worked by inclined shafts or drifts dipping about 1 in 3. The coal lies at a comparatively-low inclination and very little water is encountered. The section of the seam is as follows:—Roof: fire-clay; seam: coal, 7 inches; shale, 4 inches; coal, 7 inches; shale, 3 inches; coal, 5 inches; shale, 5 inches; and coal, 14 inches.

The mode of working is by longwall, which is very suitable, as the yielding fire-clay roof settles down gradually on to the packs or buildings. The top bed is usually left, so as to ensure a good roof.

About 15 years ago, compressed-air coal-cutters of the Gillot-and-Copley type were introduced, but they did not prove a success, as the undercutting was made in the shale, 5 inches thick, above the lowest coal.

Fire-bricks and drain-tiles of excellent quality are manufactured from the seam of fire-clay forming the roof and brushing: the output for a few recent years being:—1897, 440 tons;

1898, 1,240 tons; 1899, 1,260 tons; 1900, 1,090 tons; 1901, 900 tons; 1902, 670 tons; and 1903, 60 tons.

The same seam is also worked at the Wallsend collieries, about 1 mile to the north, by means of an inclined shaft. In this locality only one workable seam is found, although a seam of inferior coal, 3 to 8 inches thick, is found sometimes, about 25 feet above the main coal-seam.

A bore-hole, sunk near Cyphergat in 1882, proved that the top of the Beaufort Beds was about 340 feet below the coal-seam: the intervening strata being light-coloured sandstones and shales, with occasional coaly streaks. Numerous prospecting shafts and bore-holes have been sunk between Cyphergat and Molteno, but with unsatisfactory results.

Molteno is a thriving township in the centre of a rich pastoral country, 213 miles from East London by rail, and coal has been mined in the neighbourhood since 1864. The main feature of the country in this locality is the low krantzes or ledges of coarse-grained sandstone, with occasional kopjes of dolerite.

The seam, which appears to be the same as that worked at Cyphergat, is also found at a comparatively shallow depth, and is mined in a similar manner. The following is a section taken near the town:—Roof: sandstone; seam: coal, 7 inches; shale, 7 inches; coal, 9½ inches; shale, 8 inches; coal, 12 inches; and floor: shale.

About 4 miles to the south-west, the seam mined at Paardekraal and Penshaw collieries is of the following section:—Roof: shale; seam: coal, 8 inches; shale, 6 inches; coal, 10 inches; shale, 3½ inches; coal, 2½ inches; shale, 4 inches; coal, 11 inches; and floor: shale.

The bands of shale above-mentioned are not unlike the oil-shales of West Lothian, being rich in volatile matter and cleaving readily from the coal. The coal is of a bituminous nature, and burns with a long flame; but the proportion of incombustible matter is large, varying from 22 to 34 per cent.

A large coal-bearing area has been located in the valleys to the north-west of Molteno, and to develop this ground, a branch-line (17½ miles long) was built from Bamboes Siding (4 miles west of Stormberg Junction) on the Junction Line.

The principal mines are the Cape collieries (at the terminus), Zandfontein, Speedwell, Silkstone and Contats mines, but the output is comparatively small.

About 6 miles from the terminus of the branch-railway, and 9 miles from Molteno, a coal-seam has been worked on the Romansfontein farm, containing about 29 inches of coal of fair quality, but much split up by shale-bands. At this place, a conglomerate seam, composed of fossil tree-trunks and ironstone-nodules cemented together in sandstone, forms the roof.

II.—Indwe or Central Coal-field.

The Indwe coal-field is situated in the divisions of Wodehouse, Glen Grey, Xalanga and Elliot, about 50 miles to the east of the Stormberg coal-field, and the township of Indwe (formed in 1896) is about the centre. Indwe is 67 miles from Sterkstroom, 102 miles from Queenstown and 256 miles from East London by rail, whilst Elliot township is 48 miles to the eastward on the Cape-Natal Junction Railway (Figs. 2 and 3, Plate VII.).

The coal-seams are found about the middle portion of the Molteno Beds, and their outcrops are exposed in numerous valleys of streams which flow into the Cacadu, Doorn and Indwe rivers. On the north, they dip under the Waschbank mountains (spurs of the Drakensberg); and on the east, they extend into the Tembuland or Cala coal-field, although a considerable area between Papasi and Embokotwa has only been partly proved.

The southern boundary is the mountainous region extending from Seplan, *via* Indwe Poort and north of Lady Frere to Mount Arthur (on the southern slope of which the Beaufort Beds outcrop), whilst the western limit would appear to be the hilly ground from Mount Arthur *via* Inkapusi and Snowhill to the hills on the west of the Umhlanga native location, where the Red Beds are seen at the surface.

The area is about 400 square miles, but owing to denudation only about one-third contains the section of the Molteno Beds in which the coal-seams are found. The eruptive dolerite, which was the means of preserving the remainder, has so affected the coal-seams over large areas as to render them of no use as fuel.

The Molteno Beds have already been described, but Table V.

contains a detailed section of the strata in the lower portion, taken near Indwe township.

TABLE V.—SECTION OF THE MOLTENO BEDS IN INDWE TOWNSHIP.

No.	Description of Strata.	Thickness of Strata. Ft.	No.	Description of Strata.	Thickness of Strata. Ft.
1	Greyish coarse-grained sandstone, with occasional quartzite-pebbles	110	10	Light-coloured, fine-grained sandstone	100
	Upper or Flying Coal-seam—		11	Conglomerate-bed	2
2	COAL	1	12	Sandstone	6
3	Fire-clay	1	13	Buff-coloured shale	4
4	Coarse sandstone, *coal* laminations	80	14	Fine sandstone, with occasional thin shale-beds	170
	Indwe Coal-seam—		15	Soft brown sandstone, with thin beds of yellow shale	17
5	COAL and shale	12	16	Red shales and sandstones, top of Beaufort Beds below ...	...
6	Fine-grained sandstone	30			
7	Fire-clay	2		Total height of section ...	665
8	Fine-grained sandstone... ...	90			
9	Buff and purple shales	40			

The lower portion of the 90 feet of sandstone (lying below the Indwe coal-seam) is an easily quarried freestone of excellent quality for building purposes, and hardens on exposure to weather. All the coal-seams in this coal-field are of a more or less anthracitic nature, owing to the influence of the dolerite in the form of dykes or sheets, and in many instances of both.

The seam is composed of various layers of coal and shale, and each separate layer seems to preserve its distinguishing characteristics over large areas; hitherto, only one seam of workable thickness has been found in one section of strata.

The seam worked at the Indwe mines lies about 4,500 feet above sea-level, and 450 feet above the top of the Beaufort Beds, as proved by surface-exposures and bore-holes.

The main coal-seam is found in the same stratigraphical position, but of entirely different thicknesses, and Table VI. records some of the sections together with the heights above the sea-level.

TABLE VI.—SECTIONS OF COAL-SEAMS OF THE MOLTENO SERIES.

No. 1.—BAZEA, 45 MILES EAST OF INDWE.

No	Description of Strata.	Thickness of Strata. Ft. In.	Ft. In.	No.	Description of Strata.	Thickness of Strata. Ft. In.	Ft. In.
1	Sandstone	...		7	COAL	0 5	
2	Shale	0 6		8	Shale	0 9	
3	COAL	0 4		9	COAL	0 3	
4	Shale	0 2		10	Shale	...	
5	COAL	0 2					3 3
6	Shale	0 8					

TABLE VI.—*Continued.*

No. 2.—QUOTENYI, 27 MILES EAST OF INDWE.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In.	Ft.	In.
1	Sandstone	...				6	COAL	0	6		
2	COAL	0	1			7	Shale	0	7		
3	Shale	0	7			8	COAL	0	8		
4	COAL	0	6					——		3	4
5	*Coaly* shale	0	5								

No. 3.—CALA, 20 MILES EAST OF INDWE.

No.	Description	Ft.	In.	Ft.	In.	No.	Description	Ft.	In.	Ft.	In.
1	Sandstone	...				6	Shale	0	5		
2	Shale	0	4			7	COAL, inferior ...	0	3		
3	COAL	1	0			8	Sandstone	...			
4	Shale	0	2					——		2	10
5	COAL	0	8								

No. 4.—LICHFIELD FARM, 5 MILES SOUTH-EAST OF THE INDWE MINES.
Height above sea-level, 4,510 feet. Specific gravity, 1·65.

No.	Description	Ft.	In.	Ft.	In.	No.	Description	Ft.	In.	Ft.	In.
1	Sandstone	...				9	Shale	0	7		
2	COAL	0	6			10	COAL	0	2½		
3	Shale	0	7			11	Shale	0	8½		
4	COAL	1	5½			12	COAL	0	3		
5	Shale	0	2½			13	Shale	0	4		
6	COAL ...	1	5			14	COAL	0	9		
7	Shale	0	8			15	Sandstone	..			
8	COAL	0	2					——		7	10

No. 5.—ENDONGA HILL, 10 MILES SOUTH OF THE INDWE MINES.
Height above sea-level, 5,600 feet. Specific gravity, 1·56.

No.	Description	Ft.	In.	Ft.	In.	No.	Description	Ft.	In.	Ft.	In.
1	Sandstone	...				6	COAL	0	2		
2	COAL	1	2			7	Hard shale	0	6½		
3	Hard shale	0	3			8	COAL and shale, mixed	0	4		
4	COAL	0	2			9	Shale	...			
5	Dolerite, with *coaly* streaks	2	3					——		4	10½

No. 6. MACUBENI COMMONAGE, 7 MILES SOUTH-WEST OF THE INDWE MINES.
Height above sea-level, 4,220 feet. Specific gravity, 1·48.

No.	Description	Ft.	In.	Ft.	In.	No.	Description	Ft.	In.	Ft.	In.
1	Sandstone	...				8	Shale	0	1		
2	Shale	0	9			9	Shale and *coal*, mixed	0	4		
3	COAL	0	7			10	COAL	2	1		
4	Shale	0	2			11	Fire-clay, with fossil ferns	0	1		
5	COAL	0	3			12	Shale	...			
6	Shale and *coal*, mixed	0	3								
7	COAL	0	7					——		5	2

No. 7.—MACUBENI, 9 MILES SOUTH-WEST OF INDWE.

No.	Description	Ft.	In.	Ft.	In.	No.	Description	Ft.	In.	Ft.	In.
1	Sandstone	...				7	COAL	0	3		
2	Shale	0	4			8	Shale	0	3		
3	COAL	0	4			9	COAL	2	0		
4	Shale	0	2			10	Fire-clay	0	1		
5	COAL	0	1			11	Sandstone	...			
6	Shale	0	2½					——		3	8½

TABLE VI.—*Continued.*

No. 8.—INDWE MINE. Height above sea-level, 4,500 Feet.
Specific gravity: average of coal in the section, 1·55.

No.	Description of Strata.	Thickness of Strata. Ft. In.	Ft. In.	No.	Description of Strata.	Thickness of Strata. Ft. In.	Ft. In.
1	Sandstone	...		15	Shale	0 10	
2	COAL	0 9		16	COAL, inferior ...	0 5	
3	Shale	0 4		17	COAL	0 5½	
4	COAL, inferior ...	0 4		18	Shale	0 4	
5	COAL	0 6		19	COAL	0 3	
6	Fire-clay, shaly ...	0 10		20	Fire-clay, shaly ...	0 5	
7	COAL, shaly, inferior	0 3		21	COAL	0 2½	
8	COAL	0 6		22	Shale	1 10	
9	Shale	0 2		23	COAL	0 2	
10	COAL	0 10		24	COAL	0 10½	
11	Shale	0 1		25	Shale	0 8	
12	COAL	0 6		26	COAL and shaly fire-clay	0 8½	
13	Shale	0 8		27	Sandstone	...	
14	COAL	0 11				——	13 10

No. 9.—PERSEKE PLATS, 5 MILES NORTH-WEST OF THE INDWE MINE.
Height above sea-level, 4,370 feet. Specific gravity, 1·76.

No.	Description of Strata.	Ft. In.	Ft. In.	No.	Description of Strata.	Ft. In.	Ft. In.
1	Sandstone	...		7	Shale	0 4	
2	Shale	0 6		8	COAL	0 2	
3	COAL, blind ..	0 6		9	COAL, stony ...	1 1	
4	COAL	1 1		10	Shale	0 6	
5	COAL, stony ...	0 3		11	Shale	...	
6	COAL	0 8				——	5 1

No. 10.—CARNARVON, 9 MILES EAST OF STERKSTROOM.

No.	Description of Strata.	Ft. In.	Ft. In.	No.	Description of Strata.	Ft. In.	Ft. In.
1	Sandstone	...		8	COAL, inferior .	0 6	
2	Shale ...	0 7		9	Shale	0 3	
3	COAL	0 5		10	COAL	0 3	
4	Shale	0 4		11	Shale	0 4	
5	COAL, shaly ...	0 3		12	COAL	0 7	
6	COAL ...	0 4		13	Shale	...	
7	Shale	0 4				——	4 2

No. 11.—CYPHERGAT, 3 MILES SOUTH-EAST OF MOLTENO.

No.	Description of Strata.	Ft. In.	Ft. In.	No.	Description of Strata.	Ft. In.	Ft. In.
1	Fire-clay	...		6	COAL	0 5	
2	COAL	0 7		7	Shale	0 5	
3	Shale ...	0 4		8	COAL	1 2	
4	COAL	0 7		9	Shale	...	
5	Shale	0 3				——	3 9

No. 12.—CAPE COLLIERIES, 9 MILES WEST OF MOLTENO.

No.	Description of Strata.	Ft. In.	Ft. In.	No.	Description of Strata.	Ft. In.	Ft. In.
1	Fire-clay	...		6	Shale	0 8	
2	COAL, shaly ...	0 5		7	COAL	1 0	
3	COAL	0 5		8	Shale	...	
4	Shale	0 8				——	4 2
5	COAL	1 0					

Above 100 feet above the Indwe coal-seam (No. 8 section, Table VI.), a seam of mixed coal and shale, 12 inches thick,

underlain by 12 inches of white fire-clay, is found in some places; and, occasionally, a thin bed of coaly fire-clay is seen 25 to 30 feet below the main seam.

At 120 feet above the seam shewn in No. 6 section (Table VI.), a worthless mixed seam is found occasionally. The following section was taken in one of the valleys of the Guba river: Sandstone; shaly fire-clay, 3 feet 6 inches; shale 2 inches; coal, 2 inches; shale, 2 feet 9 inches; coal, inferior, 1 foot; shale, 3 inches; and sandstone-floor.

In the sandstone immediately above the Indwe seam, bands of very pure coal have been noticed, in large falls of roof, during mining operations. One sample, when tested, contained 71 per cent. of fixed carbon and only 1·41 per cent. of ash.

Taking the district as a whole, the inclination of the strata is very slight, and in a north-north-easterly direction; the dolerite-dykes have affected the dip locally in some instances, but as a rule it does not exceed 4 degrees. Fig. 7 (Plate VIII.) shews a section of the coal-seam, disturbed by a dolerite-dyke, which has since been denuded.

The presence of coal-seams was first noticed in 1877, where the Indwe main coal-seam was found cropping out in a native-footpath about 1 mile east of the present township, the ground then being a native location or reserve occupied by Tambookies. The coal-field has been reported on by Messrs. F. W. North, E. J. Dunn, and W. Galloway, the latter of whom reported on the district specially for the Government, with a view to purchase, and contributed an interesting paper on the same subject.*

No. 8 section (Table VI.) was taken near the original place of

TABLE VII.—COMPARATIVE ANALYSES OF COAL FROM INDWE, CAPE COLONY, AND SOUTH WALES.

	Indwe. Per cent.	South Wales. Per cent.
Carbon	61·021	90·55
Hydrogen	3·028	4·14
Nitrogen	2·190	1·26
Sulphur	0·434	0·45
Oxygen	2·178	2·35
Ash	30·320	0·67
Coke	75·260	85·68
Specific gravity	1·587	1·31

* "The South African Coal-field," by Mr. W. Galloway, *Transactions of the South Wales Institute of Engineers*, 1890, vol. xvii., page 67.

discovery. Table VII. contains an analysis of this coal made at Cape Town on behalf of the Government, together with an analysis of South Wales steam-coal. This sample of Indwe coal was taken near the outcrop, and does not represent the average quality disposed of at a later date.

The Indwe mines were worked in a desultory manner, and prospecting operations carried on principally by drives in the hill-side, until 1896, when a branch-railway was constructed from Sterkstroom. Since that date, the Indwe Railway, Collieries and Land Company, Limited, who had acquired the greater portion of the proved coal-bearing ground in the district, have very successfully developed the field, and equipped the mines with up-to-date machinery and plant.

Prior to the completion of the railway-line, the total output was about 30,000 tons per annum, the whole of which was transported by bullock-wagon to Dordrecht, Queenstown and Middelburg Road (on the Midland Railway system). The output from 1895 to 1903 has been about 810,000 tons.

The seam is excellently situated for economical mining, as it can be worked by adits from the hill-side, and in no part (of the present mining area) is the coal-seam more than 300 feet deep.

There is comparatively little water in the mines, and fire-damp, though found to the dip, does not give much trouble; but, in the deeper areas, it may have to be reckoned with, especially if sheet-dolerite is found between the seam and the surface. A bore-hole, put down about 4 miles east of the Indwe township, encountered a strong blower of gas at a depth of about 500 feet. It came to the surface, and, when ignited, burned with a pale-blue flame.

III.—Eastern or Tembuland Coal-field.

The Tembuland coal-field is bounded on the west by the Indwe coal-field, and may be considered as an extension of the same.

The thick ledge of sandstone above the horizon of the Indwe coal-seam can easily be traced, in the valleys of the Lafuta and other streams, which rise in the Umtingwevu and Umcoul Hills and flow into the Tsomo river, below Cala township. Although thin beds of coaly shale have been noticed, no seam of any consequence has been discovered, so far southward. To the

north-westward of Cala, between the Cala and Spafa streams, a drift has been driven under a krantz for a considerable distance, and, judging by aneroid-barometer levels and the fact that the Indwe coarse sandstone lies above it, it is likely to be the Indwe coal-seam. The following is a section of this seam:—Roof: sandstone; seam: shale, 4 inches; coal, 1 foot; shale, 2 inches; coal, 8 inches; shale, 5 inches; and coal, inferior, 3 inches; and floor: sandstone. The following is an analysis of the seam by the Government chemist:—Fixed carbon, 68·51 per cent.; volatile matter, 9·50 per cent.; moisture, 1·50 per cent.; ash, 19·70 per cent.; and sulphur, 0·79 per cent.

Near the top of the cutting on the main road from Cala to Elliot and Barkly East, a seam is exposed under a low sandstone-cliff, which the writer measured as follows:—Roof: sandstone; seam: coal and shale, 3 inches; shale, 3 inches; coal, 2½ inches; shaly fire-clay, 3 feet 4 inches; coal, 8 inches; and floor: shale. Fossil plant-remains are found close by, and, judging by aneroid-barometer levels and the height above the Karroo Beds, it appears to represent the Upper or Flying coal-seam of the Indwe district.

A seam, apparently occupying the same position, is found in one of the sources of the Umgwana river, but it is much affected by dolerite. This seam has the following section:—Roof: sandstone; seam: coal, 7 inches; shale, 1 inch; coal, 7 inches; shale, ½ inch; coal, 4 inches; shale, 1 foot 6 inches; and floor: shale.

In a densely wooded valley formed by a stream running into the Emgwali river, a considerable amount of drifting has been done in a seam, which crops out on both sides of the creek. This place is about 9 miles east of Cala and 3,550 feet above sea-level. An average section is as follows:—Roof: sandstone; seam: coal, 1 inch; shale, 7 inches; coal, 6 inches; coal, mixed with shale, 3 inches; coal, 6 inches; shale, 7 inches; coal, 8 inches; shale, 2 feet; and floor: shale. The coal is highly anthracitic, but it contains 14 per cent. of ash.

The Beaufort Beds have been found at the foot of a gorge close at hand, and 500 feet below the coal-seam; but though the strata are exposed for the greater part, no Carboniferous deposit has been observed.

Thin coal-seams have been discovered by natives, who by their experience gained in the collieries appreciate the value of coal,

in the precipitous valleys of the Emgwali and Bashee districts; but their distance from market, the want of proper roads, and the comparative thinness of the seams, render their working unprofitable.

In the Bazea Hills, 45 miles due east of the Indwe mines, the writer was shewn a seam in a cave underneath a low krantz. This seam has the following section:—Roof: sandstone; seam: shale, 6 inches; coal, 4 inches; shale, 2 inches; coal, 2 inches; shale, 8 inches; coal, 5 inches; shale, 9 inches; coal, 3 inches; and floor: shale. The height above sea-level is 3,720 feet.

The Junction Railway between the Cape Colony and Natal systems of railways keeps about the level of the Molteno Beds, and coal-seams have been found at many places on the route.

At the junction of Klein and Groot Tsomo rivers, a thin coal-seam is found, whilst Mr. W. Galloway, in 1889,* gives the following section of a seam on the Newcastle farm, about 40 miles from Cala:—Roof: shale; seam: coal, 7 inches; shale, 3 inches; coal, 5 inches; coal and shale, 4 inches; coal, 3 inches; shale, ½ inch; coal, 7 inches; floor: fire-clay and shale, 7 feet.

The Elliot district, on its southern boundary, contains numerous outcrops, but all of thin seams, too much intermixed with shale to be of any value; and the same remarks apply to the seams of the Maclear and Matatiele districts.

The seams generally occupy the same position as farther east, namely, 400 to 600 feet above the top of the Beaufort Beds. To the east of Matatiele, a coal-seam with Torbanehill mineral (found above the Woodend ironstone-horizon in the Bathgate district, West Lothian), associated with it, has been found of the following section:—Molteno Sandstone krantz; grey shales, thinly laminated and carbonaceous; grey sandstone, 1 inch; carbonaceous shale, thinly laminated, 2 feet 11 inches; drab sandstone, with large white mica-flakes, 4 inches; carbonaceous shale, 1 foot 6 inches; coal, 9 inches; drab sandstone, 3 inches; coal, 1 foot; compact carbonaceous shale, splint or torbanite, 1 foot 2 inches; laminated shale, highly carbonaceous, 2 feet 3 inches; grey shales, with ironstone-nodules, 10 inches; and blue shales and sandstones. The following are comparative analyses of the Matatiele splint or torbanite and of the Torbanehill mineral:—

* *Report upon the Coal-deposits in the Indwe Basin and Stormberg Range of Mountains*, by Mr. W. Galloway, 1889.

	Matatiele Mineral. Per cent.	Torbanehill Mineral. Per cent.
Moisture	1·32	...
Volatile organic matter	18·16	70·10
Fixed carbon	32·37	10·30
Ash	47·26	19·60
Sulphur	0·89	...
Yield of oil per ton gallons	25	120

The following is an analysis of the coal lying above the Torbanehill mineral at Matatiele:—Moisture, 1·37 per cent.; volatile matter, 24·68 per cent.; fixed carbon, 47·53 per cent.; ash, 25·10 per cent.; and sulphur, 1·32 per cent.

As the country becomes more widely settled, there is every probability that workable coal-seams will be discovered between Matatiele and Natal, along the slopes of the Drakensberg, as there can be no doubt that the Natal coal-fields are of the same age as those found in the Cape Colony.

IV.—Outlying Coal-fields.

Coal has been discovered in other parts of Cape Colony: but, hitherto, the extent of the deposits has been so limited or the quality so poor, that they were found to be of no commercial value.

In the shafts at the diamond-mines at Kimberley, shales of a carbonaceous nature have been encountered, containing pieces of fossilized wood, but no true coal-seam has been found.

In 1864, an almost vertical fissure filled with coal was discovered in the mountain-side at Leeuws River Poort in the Beaufort West district, about 4,200 feet above sea-level, and 240 miles due south-west from Sterkstroom. It proved, however, to be a very irregular deposit, and after it had been explored and about 200 tons had been extracted, it pinched out. An analysis by the Government chemist of a sample gave the following result:—Coke, 80·19 per cent.; ash, 0·80 per cent.; volatile matter, 18·33 per cent.; and water 0·68 per cent. The specific gravity was 1·17. The deposit was found in the Ecca Beds, and the enclosing rock was sandstone. In the same locality, similar stringers of coal and lignite have been found.

In the Camdeboo mountains, a few miles from Aberdeen township, 100 miles eastwards from the previous-mentioned locality, and 4,000 feet above sea-level, small pieces of coal and

black shale were discovered by a native herdsman in 1876. The surface was opened, and a mixed deposit of shale and coal, highly anthracitic in character, was found in a contorted mass, similar to that occasionally found in the "vees" of a fault. Fossil impressions of *Glossopteris* and *Calamites* were recognized. The coal was of excellent quality, as shewn by the undernoted analysis:—Volatile matter, 3·70 per cent.; coke, 95·21 per cent.; ash, 1·09 per cent.; and sulphur, *nil*. The specific gravity was 1·40. Only a small tonnage of coal was wrought before the deposit pinched out in the sandstone.

In the Laingsburg and Prince Albert districts, thin coal-seams are found under similar circumstances, in vertical lenticular patches in the shales, but the quantity is very small.

There are many engineers who, relying on the above discoveries, and other indications, believe in the existence of a large coal-field in the Great Karroo in or underlying the Beaufort Beds; more especially as the Coal-measures rest directly on the Dwyka Conglomerate in the Southern Transvaal, at Viljoens Drift. Mr. E. J. Dunn was a strong supporter of this theory, and on his advice, four bore-holes were sunk in 1886 at various places in the Great Karroo, as under, but no coal-seams were encountered: Potfontein station, 821 feet deep; Fraserburg Road station, 1,080 feet and 1,110 feet deep; and at Camdeboo mountains, 2,030 feet deep.

During the past twenty years, the strata in the Great Karroo have been tested in numerous localities by artesian wells, sunk for irrigation-purposes, and no valuable carboniferous deposit has been discovered; but, at present, prospecting operations by means of diamond drill-holes are being carried on in search of coal in the Prince Albert district.

In the Barkly East district, the rivers flow into the Orange river, and it is thought that there is a likelihood of coal being got on the northern slopes of the Drakensberg, corresponding to the seams found in the Elliot and Maclear districts on the southern slope; but all operations, hitherto, have been unsuccessful. Near the junction of the Kraai river and the Sterkspruit in the Barkly East division, the writer noticed thin streaks of carbonaceous shale interbedded with sandstone and reddish shales, and also saw plastic bituminous matter in limestone. In all probability, these measures were in the Molteno Beds, as

300 or 400 feet higher up the valley, and to the south, the Red Beds were found, with the Cave Sandstone on the top, near the head of the Barkly Pass.

To the north-west of this locality in the Herschel district, on the border of the Orange River Colony, thin stringers of coal and carbonaceous matter have been found, of excellent quality, but in such small quantities as to be unworkable. Similar seams have been found near Jamestown, to the south of Herschel, accompanied by fossil trees, standing perpendicular. The following is an analysis by the Government chemist of a sample from Herschel:—Coke and ash, 71·42 per cent.; ash, 19·70 per cent.; volatile matter, 26·58 per cent.; and water, 6·35 per cent. The specific gravity was 1·51.

Quality of Coal and Markets.

All the coal of Cape Colony seems to have been more or less affected by volcanic agencies, but the Stormberg coals are not so highly anthracitic as those in the Indwe and Cala districts. It is noticeable that the shale cannot be cleaved or parted from the coal so easily when it is low in volatile matter, as when it is highly bituminous. Although the interstratified bands of coal and shale are comparatively thin, yet they retain their distinguishing characteristic features wherever found, and vary very little in thickness or quality over a large area.

The great drawback to the coal of Cape Colony is the high percentage of incombustible matter in the coal; and this is so intermixed with the coal that, unless the whole seam were ground to a powder, and then carefully washed, it would be impossible to separate them.

The cost of producing the coal is enhanced by the fact that when chopping the shale off the coal-seam, both underground and on the surface, a layer of coal often breaks off with the shale, and is thrown into the goaf or over the waste-heap. It would not be too much to allow 7 per cent. as the waste of coal by this operation.

Table VIII. contains the results of analyses of some of the coals of Cape Colony. Table IX. contains analyses of coals from other districts in South Africa.

There is a great difference of quality in the various seams or bands of coal, and even in the same mineral-field, the identical

seam will vary in capacity for steam-raising, and each coal requires a distinct method of firing. Table X. contains the results of trials made by the Locomotive Department of the Cape Government Railways in 1899, with a view to arriving at the

TABLE VIII.—ANALYSES OF CAPE COLONY COALS.

	Cala * Per cent.	Engcobo.* Per cent.	Glen Grey.† Per cent.	Indwe.† Per cent.	Matatiele.* Per cent.	Molteno.† Per cent.	Quotenyi.† Per cent.
Fixed carbon ...	68·51	67·14	60·90	54·44	47·53	49·30	61·10
Volatile matter	9·50	10·99	20·44	25·05	24·68	23·62	12·71
Ash	19·70	20·01	17·31	19·38	25·10	24·86	23·80
Sulphur	0·79	0·76	0·42	Trace	1·33	0·85	0·67
Moisture ...	1·50	1·10	0·93	1·13	1·36	1·37	1·72
Weight of water evaporated by 1 pound of coal ... pounds	9·9	—	12·1	11·3	—	9·1	10·7

* Analysed by the Government chemist. † These samples were taken by the writer in 1901.

TABLE IX.—ANALYSES OF SOUTH AFRICAN COALS.

	Wankie.	Rhodesia. Sebungu.	Tuli.	Zululand, St. Lucia Bay.
Fixed carbon ...	68·29	44·04	57·20	77·10
Volatile matter ...	19·73	31·27	15·32	10·80
Ash	10·22	23·18	25·23	10·40
Sulphur	1·06	0·69	0·39	—
Moisture	0·70	0·82	1·86	1·70

	Transvaal. Middelburg.	Transvaal. Springs.	Natal. North District.	Natal. South District.
Fixed carbon ...	70·83	50·04	68·96	58·67
Volatile matter ...	21·38	16·70	19·91	16·60
Ash	6·82	25·52	8·63	20·37
Sulphur	0·45	0·41	1·20	3·31
Moisture	0·52	7·33	1·30	1·05

TABLE X.—RELATIVE VALUES OF COALS TESTED BY THE LOCOMOTIVE DEPARTMENT OF THE CAPE GOVERNMENT RAILWAYS.

	Weight of Coal giving equal effect.
South Wales: Ocean Merthyr	1·00
United States of North America: Pocahontas ...	1·20
Natal: Dundee Navigation	1·25
Orange River Colony: Vereeniging	1·60
Cape Colony:	
Indwe	1·80
Stormberg: Contats	1·50
,, Penshaw	1·60
,, Cape Collieries	1·75
,, Cyphergat	2·00
,, Fairview	2·00
,, Wallsend	2·00
,, Molteno	2·00

relative values of Colonial coals, compared with Welsh steam-coal. The writer does not think that these trials fairly represent the actual value of the various coals, and he considers that the following values of the weight of coal to produce an equal effect form a more accurate comparison: Ocean Merthyr, 1·00; Natal, average of collieries, 1·30; Vereeniging, 1·45; Indwe, 1·50; and Stormberg, average of collieries, 1·75.

It will be recognized from the preceding analyses (Table VIII.) that the Cape Colony seams are inferior in quality to the majority of South African coals; hence the area within which they can successfully be used is comparatively limited, and a large output is unattainable on account of their distance by rail from the large centres of population.

The Natal collieries, their greatest competitors, are situated close to the main line of railway from Durban to Johannesburg; and empty trucks, which have gone north to the Rand loaded with goods and machinery, can on their return-journey carry coal down to the coast at a very low rate per ton. The Natal collieries are about 240 miles distant from Durban and the railway-rate per ton is 9s., so that, taking the average selling price at 11s. 9d. per ton,* coal can be delivered into ships for 21s. 6d. per ton. The Natal Government allow a rebate of 2s. 6d. per ton, if the coal is exported. Consequently, Natal coal can be delivered at East London or Port Elizabeth for 22s. or 23s. per ton, whilst Welsh coal costs about 28s. per ton delivered at these ports.

The average selling price of Cape Colony coal at the mine is 15s. 6d. per ton, and the average distance to East London, the nearest seaport, is also about 240 miles. Consequently, even with the same rate for railway-carriage as Natal, the coal would cost 24s. 6d. per ton at the port of East London, and, therefore, could hardly compete against Natal, especially considering that the latter is 15 to 20 per cent. superior in quality.

The diamond-mines and town of Kimberley for many years have been supplied by Cape Colony with coal, but the construction of the new railways in Orange River Colony, has allowed Natal to compete here also. In the near future, the coal-mines at Vierfontein, in the Orange River Colony, will be connected by a railway from Fourteen Streams, and these mines, being

* *Report on the Mining Industries of Natal for the Year 1903*, 1904, page 58.

nearer Kimberley than the Stormberg, will affect the output of the latter to some extent.

Tables XI. and XII. indicate the progress of the coal-mining industry in the Cape Colony since 1884. Table XII. has been compiled from the annual reports of the Government Inspector of Mines.

TABLE XI.—COAL-OUTPUT OF THE CAPE COLONY IN TONS OF 2,000 POUNDS FROM 1885 TO 1896.

Year.	Tons.	Year.	Tons.	Year.	Tons.
1885 ...	15,000	1889 ...	23,000	1893 ...	53,000
1886 ...	19,000	1890 ...	29,000	1894 ...	62,000
1887 ...	19,000	1891 ...	25,000	1895 ...	77,000
1888 ...	29,000	1892 ...	37,000	1896 ...	94,000

TABLE XII.—COAL-OUTPUT, WORK-PEOPLE AND DEATH-RATE FROM ACCIDENTS FROM 1897.

Year.	Coal Raised. Tons.	Value of Coal per Ton. s. d.	Employees. White.	Employees. Native.	No. of Native Employees per White Man.	Output per Native Employee per Annum. Tons.	Death-rate from Accidents per 1,000 Employees.
1897	127,513	...	160	2,032	12·7	62·7	...
1898	191,858	12 5	147	2,833	19·3	65·4	3·691
1899	208,655	12 10	143	2,843	19·8	73·4	2·344
1900	198,451	15 4½	171	3,286	19·2	60·4	3·182
1901	205,810	17 6	128	2,462	19·2	83·7	1·545
1902	185,424	17 1½	141	2,055	14·6	90·2	1·821
1903	207,493	17 3	131	2,169	16·6	95·7	1·304

The following statistics of Natal for 1903, are given for purposes of comparison:—Coal, 713,548 tons; white employees, 211; native and Indian employees, 4,303; total number of employees, 4,514; number of native and Indian employees per white employee, 20; output per native and Indian employee per annum, 166 tons; death-rate per 1,000 employees, 2·64; and estimated value of coal at the mine, 11s. 9d. per ton.

Although at present there is no prospect of the coal-industry of Cape Colony attaining to anything like the proportions of that of Natal or the Transvaal, yet it will always be a great asset to that colony, considering the mileage of railway-lines in the Eastern province, and the writer trusts that this paper may be the means of arousing interest in a coal-field, hitherto, comparatively neglected.

The methods of working, native-labour question, etc., have not been considered in this paper, as there are no very special or outstanding features in connection with the same.

The following notes record some of the features of interest seen by the visitors to collieries, which were, by kind permission of the owners, open for inspection:—

FIFE COAL COMPANY, LIMITED.

AITKEN PIT, KELTY.

The Aitken pit, 1,260 feet deep to the Dunfermline Splint coal-seam, is 26 feet long and 11 feet wide. The sinking was begun in March, 1894, and the Bank or Lochgelly Splint, the Five-feet and the Dunfermline Splint seams have been opened out.

The main pumping-engine is of the compound-condensing type, the high-pressure cylinder being 57 inches in diameter and the low-pressure cylinder 84 inches in diameter. The engine is worked in connection with a balance-beam, to equalize the load in the up and down strokes of the engine. The pumps are divided into four stages. In the first and second stages, the rams are 30 inches in diameter; in the third stage, the ram is 24 inches in diameter; and there is a bucket 20 inches in diameter for the fourth stage, all having a stroke of 13 feet. During 1904, this engine raised 2,500,000 tons of water.

Recently a Riedler pump has been laid down as a stand-bye. This engine has a high-pressure cylinder, 24 inches in diameter and a low-pressure cylinder, 40 inches in diameter, with four pump-rams, 6 inches in diameter, all with a stroke of 3½ feet; and at 75 revolutions per minute, it delivers 1,200 gallons of water.

The dook workings are drained, principally by triple-ram pumps, electrically driven; and part of the haulage is done by electric motors placed at various positions throughout the pit. The main haulage-dook is worked by an endless rope, power being transmitted from the surface to the pit-bottom by a band-rope.

Electric power is produced by two compound-condensing engines, with high-pressure cylinders, 14 inches in diameter, and low-pressure cylinders, 24 inches in diameter, and a stroke of 3 feet. One engine drives a dynamo of 100 kilowatts, and the other engine drives a dynamo of 110 kilowatts, both at 500 volts.

The pit is ventilated by a forcing fan, 16 feet in diameter. The fan is rope-driven, the rope-wheels being in the ratio of 2 to 1. The fan, when running at 100 revolutions per minute, produces 170,000 cubic feet of air at 1½ inches of water-gauge.

The winding-engine, with two cylinders, each 32 inches in diameter and 5 feet stroke, is fitted with Frew valves. The drum is 16 feet in diameter. The pulleys are 14 feet in diameter. The single-decked cages carry 4 tubs. A balance-rope of the same weight as the winding-rope is used, and is found to be of great advantage in winding. The output of this pit for 1904 was almost exactly 500,000 tons, and the record shift's winding took place on May 9th, 1905, when 633 winds were done in 7½ hours, being an average of 84·4 winds per hour.

Steam at a pressure of 100 pounds per square ineh is got by 13 Lancashire boilers, each 30 feet long by 8 feet in diameter, partly fitted with a Green economizer.

No. 10 Pit, Cowdenbeath.

The No. 10 pit, 1,440 feet deep, is 20 feet long and 11 feet wide. The seams worked comprize the Lochgelly Splint, the Five-feet and the Dunfermline Splint.

The cages are double-decked, carrying two tubs (tandem) on each. The decks are loaded and discharged simultaneously, and for this purpose auxiliary cages are used at the pit-head, and creeper-chains at the pit-bottom. The record-time for winding and changing is 43 seconds.

The winding-engine has two cylinders, each 30 inches in diameter and 6 feet stroke. The drum is 16 feet in diameter.

The pumping-engine at this pit is of the same type as the Lochore engine, hereinafter described, except that a Körting ejector-condenser is used here, in place of an ordinary air-pump condenser. This engine, having been at work for about 9 years, has been fairly well tested, and has worked satisfactorily. It has been frequently tested for fuel-consumption, and has always given about 75,000,000 foot-pounds for an evaporation of 1,120 pounds of water. The latest test was made in November, 1904, and gave 75,014,279 foot-pounds per 1,120 pounds of water evaporated. During 1904, this engine raised 2,400,000 tons of water, being about 11 tons of water per ton of coal raised during that period. The pumps are similar to those in the Lochore pit, in three stages, with two rams at each stage.

The haulage underground is mainly by endless rope, power being transmitted from the surface to the pit-bottom by a band-rope. The band-rope runs at a speed of 10 miles an hour; it is carried on a Clifton wheel, 10 feet in diameter, at the surface, and drives a similar wheel at the pit-bottom. The shaft carrying the latter wheel is geared into another shaft carrying three Clifton wheels, 7 feet in diameter, from which endless ropes are driven at a speed of 2½ miles an hour.

The air-compressing plant at this pit is of the compound type, the air being compressed in two stages to a pressure of 100 pounds per square inch. The high-pressure steam-cylinders are 20 inches in diameter, and the low-pressure 34 inches in diameter. The air-cylinders, for the first stage, are 29 inches in diameter, and for the second stage, 18 inches in diameter: all with a stroke of 4 feet. The compressed air is used for driving coal-cutting machines, and for pumping and hauling from dook workings.

Mary Pit, Lochore.

The Mary pit is being sunk on the bed of what was at one time the Loch of Ore. About 50 or 60 years ago, the outlet of the loch was deepened and an area of 1,000 to 1,200 acres drained, and is now used as a sheep-farm and makes very good pasture. The coal-field at this point is about 4 miles broad, north and south, that is from Benarty to the southern boundary of Lochgelly. The Mary pit is situated about ¾ mile from the northern boundary, where the Coal-measures are cut off by a great fault running east and west. The area, which this pit is intended to work, is calculated to contain upwards of 30,000,000 tons of coal in the six best seams, namely:—The Main, Jersey, Lochgelly Splint, Mynheer, Five-feet and Dunfermline Splint.

In sinking the shaft to its present depth of 1,140 feet, no less than 546 feet of whin have been cut, one bed being 381 feet thick. This bed was very hard, and rock-drills, driven by compressed air, were used throughout. In the course of sinking below the second bed of whin, a most unusual section was passed through (Fig. 1), the strata being very much contorted, and lying at all angles. The pit was sunk to a depth of 600 feet before the strata were found lying at the ordinary inclination. Under ordinary circumstances, this condition of matters would

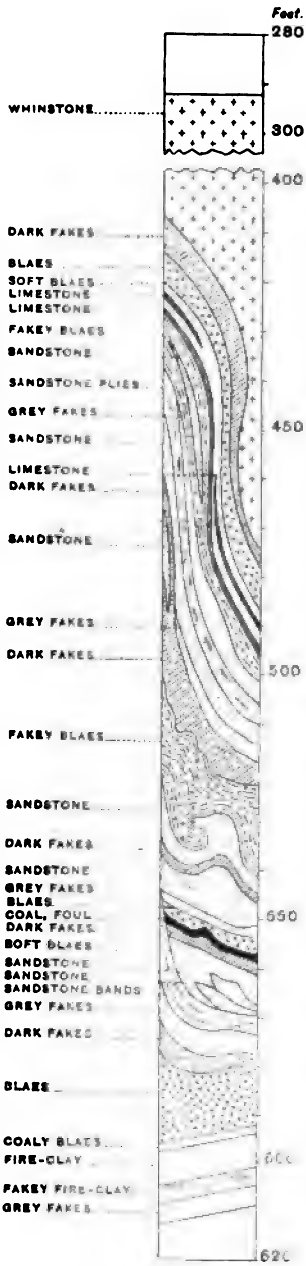

FIG. 1.—SECTION OF PART OF THE MARY PIT, LOCHORE. SCALE, 4. FEET TO 1 INCH.

have given cause for alarm regarding the state of the seams below; but the precaution had been taken of driving a pair of dooks from the Aitken pit (about 1½ miles away) for the purpose of proving the Lochore coal-field, and it was found that under the Mary pit, the Five-feet and the Dunfermline Splint seams were in splendid condition, being respectively 5½ and 3½ feet thick.

The pit, which will be 2,100 feet deep to the Dunfermline Splint seam, is 29 feet long and 11½ feet wide, and is lined throughout with pitchpine from 3 to 6 inches thick. The space is divided into four parts, one for pumping, two for winding, and the other for haulage-ropes and electric cables.

The cages will be double-decked, carrying four tubs on each deck, and arrangements will be made for loading and discharging the two decks simultaneously. The pit-head and pit-bottom will be laid out for dealing with an output of 2,000 tons in 7½ hours. The pithead-frame is of the four-leg type, built of lattice-steel girders, the main uprights being 80 feet high above the rail-level. The crab-frame is constructed of H girders and channel-irons.

The pit-head pulleys, 18 feet in diameter on the tread, are suitable for a steel rope, 2 inches in diameter. The rim is made of cast-steel in four parts, held together with bolts and hoops; and the boss is also made of cast-steel. Flat-bar arms connect the rim and boss, being bolted to each with fitted bolts. After

the wheel was built, the rim was turned true, and then carefully balanced so as to ensure steady running. The gudgeons are 9½ inches in diameter in the body, to which the pulleys are fixed with four keys. The journals are each 7 inches in diameter by 11 inches in length and run in gun-metal bushes with self-lubricating rings, which ensure continuous lubrication to each journal. The whole has been carefully designed to reduce the wear on the ropes and the journals to a minimum, and works very sweetly and true.

The 40 tons crab has two cylinders, 8 inches in diameter and 16 inches stroke, fitted with reversing-gear, throttle-valve, and all necessary fittings. The engines are geared to the drum with strong gearing counter-shafts. The drum, covered with oak staves with steel plates on the top and made suitable for a rope 2½ inches in diameter, is fitted with foot-brake and depth-indicator, and all levers are brought to a point convenient for the engineman. The total weight of the crab is 36 tons.

The winding-engine, with two cylinders, 38 inches in diameter and a stroke of 6½ feet, has two drums, each 20 feet in diameter and 6½ feet wide. The principal features of the engine are the Corliss valves to the cylinders with a steam-reverser, and a steam-brake to the drums. Each cylinder is fitted with two steam-valves and two exhaust-valves, actuated through a wrist-plate and link-motion by the eccentrics. The advantages of Corliss valves are well known: the ease of handling in reversing, the facility for examination without disturbing the valve-gear, and the rapidity with which the valves can be refaced when this becomes necessary. The piston-rods are fitted with simple metallic packings, easy to replace or adjust.

All the wearing parts have been designed with very ample surface, and provision for easy and quick adjustment. The lubrication has been carefully arranged, no part being overlooked, and all, as far as possible, is automatic. Each cylinder is fitted with a mechanical sight-feed lubricator, which supplies oil to the cylinders only when the engine is in motion.

The steam-reverser consists of a steam-cylinder with a cataract-regulator and floating levers, so arranged that perfect control of the position of the links is obtained; the gear may be notched up, as with an ordinary hand-reversing link; and the large engine is as easy to handle as the smallest size of winding-engine.

The hollow crank-shaft is 18 inches in diameter and 27 inches in length in the journals, and 20 inches in diameter in the body; the main bearings are four-part adjustable, and the bottom part may be removed by lifting the crank-shaft about ⅛ inch.

The drums, 20 feet in diameter and 6½ feet wide between the flanges, hold 39 turns of rope (2 inches in diameter or 6¼ inches in circumference) without overlapping; and 33½ revolutions of the engine will bring the cage from the pit-bottom, when the pit is sunk to the total depth of 2,100 feet. Each drum is built of two side-cheeks and a centre-bearer, cleaded with oak staves, 6 inches thick, forming the tread for the rope. On one cheek of each drum is cast a heavy brake-rim on which the brakes act. The brakes are of the post type of massive H joists, fitted with wood-wearing blocks and working on massive pins. The levers are fitted with suitable adjustments, and attached to a steam-cylinder with a cataract. A very light pressure of the foot is sufficient to apply the brakes, which operate quickly or slowly according to the application of the foot-pressure, but without shock. There is also a locking arrangement, by which the brake may be held fast without steam.

The driver's platform, of rigid construction, is placed between the cylinders, and so arranged that the engineman has all the working parts in view. The reversing, brake and steam throttle-valve levers are arranged on this platform, as also the main stop-valve, while the depth-indicator is in full view, driven from the crank-shaft between the drums.

The centres of the cylinders are 27 feet apart, and the weight of the whole engine is 230 tons.

The compound-condensing and double-acting pumping-engine has a high-pressure cylinder, 58 inches in diameter, and a low-pressure cylinder, 100 inches in diameter, both suitable for a stroke of 12 feet. They rest on a sole-plate of massive construction which again is carried on strong deep girders over the pit (Plate IX.). The cylinders are lagged with teak with massive brass bands, which give an effective finish.

The piston-rods, 10 inches in diameter, are fitted with United States metallic packings. The rods are secured to the cross-

heads by nuts and collars, and the pump-rods are bolted to the cross-heads, and have hoops fitted and shrunk on besides. The cross-heads have journals for the connecting links coupling to the bell-crank levers, afterwards described.

There are six valves on the cylinders for the admission and eduction of steam, three for the top side of the piston, and three for the bottom side: their action being described below. The valves are operated by levers from a plug or tappet-rod, and four cataracts are fitted to regulate the action of the valves: the tappet-rod being driven by one of the bell-crank levers.

The bell-crank levers are built of steel plates and channel-irons with cast-steel centres and mild-steel gudgeons and pins. The bell-crank levers are connected together by two box-section connecting rods, built of plates and angle-irons and tapering to each end, where they are fitted with massive gun-metal bushes, secured by gibs and cotters. Each connecting rod weighs about 7½ tons, and the bearings are 42 feet 8 inches apart, from centre to centre.

A continuation of one of the bell-crank levers drives the air-pump, through connecting rods and a cross-head sliding in guides attached to the top flange of the air-pump. The air-pump is 46 inches in diameter by 7 feet stroke, and is fitted to the foot-chest along with the condenser.

Bye-pass valves are fitted to the valve-chests for ease in starting, and when the engine is started the valves work in the following manner:—When the high-pressure piston is at the bottom of the stroke, boiler-steam is admitted through the steam-valve, to the underside of the piston. At the same time, the top intermediate valve is open and exhausting steam from the top side of the high-pressure cylinder to the top of the low-pressure cylinder, and the exhaust-valve on the underside of the low-pressure cylinder is open and passing exhaust-steam to the condenser. At the opposite end of the stroke, that is, when the high-pressure piston is at the top and the low-pressure piston is at the bottom of the stroke, a similar operation is performed.

The arrangement of the cylinders and levers is shewn in Plate IX.

It is believed that this is the largest pumping-engine in the United Kingdom. The total weight of the engine, with bell-crank levers, connecting rods and links, is 273 tons: the low-

pressure cylinder weighing about 22 tons and the bedplate 19 tons.

The pumps are of the usual single-acting ram type, arranged in three lifts, each with two pumps. The top lift is 660 feet; the second lift, 720 feet; the bottom lift, 720 feet; and the total lift, 2,100 feet.

The pump-rams are 21 inches in diameter, suitable for a stroke of 12 feet, each having a working barrel, connected by a T pipe to the suction-valve and discharge-valve chests. The two discharge-valve chests of each lift are connected by a Y pipe to the branch-pipe on the rising main, and the suction-rose or rattle-head is bolted to the bottom of the suction-valve chest. The valve-seats and valves are of steel, the latter having vulcanite-faces, rivetted on.

The working barrels and rising main are supported on three massive girders, secured to sole-plates, one at each end; and the chests are carried on the wall of the lodgment.

The pump-rods are fixed to the pump-rams by forked spear-rods, with tapered fitted ends, secured to the rams by a cotter. Massive steel cross-heads, made in halves, are fitted to the neck of the spear-rod; to each cross-head, long side-rods are attached, one on each side of the pump-barrel; and the lower ends of the side-rods are attached by a cross-tail to the pump-rods for the lower set of pumps.

The first and second sets of pumps weigh together about 270 tons.

The pump-rods are made of pitchpine, in lengths varying from 60 to 70 feet; and each joint is fitted with 4 steel plates, about 20 feet long and of suitable breadth and thickness. The pump-rods are tapered, the top rods being 22 inches square, and the bottom rods, 14 inches square. The total weight on each bell-crank is about 130 tons; and the whole length is so constructed that the tensile strain does not exceed 600 pounds per square inch for the timber, and 4,000 pounds per square inch for the plates and bolts.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING.

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, APRIL 8TH, 1905.

MR. J. H. MERIVALE, VICE-PRESIDENT, IN THE CHAIR.

The SECRETARY read the Minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on March 25th and that day.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. HUBERT ADAIR, Mining Engineer, Gillfoot, Egremont, R.S.O., Cumberland.

Mr. GEORGE HERBERT ARCHIBALD ARMSTRONG, Electrical Engineer, Castle View, Chester-le-Street, County Durham.

Mr. EDMUND JACKSON, Civil and Mining Engineer, Tangier Buildings, Whitehaven.

Mr. GEORGE HENRY ROBINSON, Jun., Mining Engineer, Asturiana Mines, Limited, Covadonga, Asturias, Spain.

Mr. ANTHONY SCOTT, Mining Engineer, Southwick House, Sunderland.

ASSOCIATE MEMBERS—

Mr. FRANK ARDINGTON, P.O. Box 661, 3, Holt's Buildings, Durban, Natal, South Africa.

Mr. WILLIAM JOHN QUINCE, P.O. Box 297, Pietermaritzburg, Natal, South Africa.

STUDENTS—

Mr. BERENT CONRAD GULLACHSEN, Mining Student, 25, Eslington Terrace, Newcastle-upon-Tyne; and Colliery Offices, New Seaham, *via* Sunderland.

Mr. ALLAN ROBINSON BOWES HUTTON, Mining Student, Peases West Colliery Offices, Crook, R.S.O., County Durham.

Mr. J. W. BATEY's paper on "The Mickley Conveyor" was read as follows;—

THE MICKLEY CONVEYOR.

By J. W. BATEY.

At the Prudhoe colliery of the Mickley Coal Company, Limited, the output is chiefly derived from the Brockwell Seam, which varies from 19 inches to about 28 inches in thickness. Immediately above the coal is a bed of shale, about 12 inches thick, containing a considerable number of shells; next occurs a bed of fine blue metal, from 5 to 6 feet thick; and this is overlain by a bed of post, of considerable thickness. The thill is a coarse fire-clay, containing iron-nodules.

There being no power at bank to work coal-cutters or mechanically-driven conveyors, a simple form of conveyor* has been introduced, to carry the coals along the face. This conveyor and its accessories are not costly; it is entirely worked by manual labour; and, since its introduction, the cost of working the coal has been very considerably reduced.

The conveyor, A, is a long shallow tub (Figs. 1 and 2, Plate X.). The box, made of thin sheet-iron, is 7 feet long at the top, tapering down to 6½ feet long at the bottom, and 2 feet 8 inches wide; the depth at the back is 11 inches, and the side next to the coal-face is 7 inches deep, thus affording the hewer more height between the top of the tub and the roof when filling coals into the tub.† The axles are placed at each end of the tub, the wheels are 6 inches in diameter, and the gauge of the conveyor-road is 2 feet 10 inches. The bottom of the conveyor is fitted with two sliding doors, which are drawn out when it is to be emptied. The height of the front side of the conveyor from the rail is 10½ inches.

* British patent, 1904, No. 16576, Mr. Sidney Bates.

† The dimensions of the conveyor should vary according to the size of the ordinary coal-tub, and should be made so that each load that the conveyor brings from the working-face will just fill a tub,

The road upon which the conveyor runs backward and forward along the face is made of ordinary bridge-rails, laid upon iron sleepers, 3 inches wide and $\frac{3}{16}$ inch thick. The ends of the sleepers are turned up to grip the outside of the rails, and a small iron clasp is attached on the inside, with a bolt and nut, to keep the rails in position. The rails, B (Figs. 1 and 2, Plate X.), are laid along the whole length of the face, and span the bottom-canch, C, which has been taken up in the main road, so as to allow the ordinary coal-tub to run underneath the rails. The conveyor is run over the coal-tub, the sliding doors are withdrawn in turn, and the coals fall directly into the tub.

The conveyor is run to and fro, along the face, by means of an endless galvanized wire-rope, $\frac{1}{4}$ inch in diameter, fastened to each end of it. The rope is turned one-and-a-half times round the driving-wheel, and has a single turn on the return-wheel. The driving-wheel, D, is an ordinary pulley-wheel, 18 inches in diameter, with a groove, $1\frac{1}{2}$ inches wide. The spindle which carries the driving-wheel is fixed to the frame or standard of an ordinary stone-boring machine, and is set, between the conveyor-rails, on the far side of the tub-way. A handle, about 12 inches long, is fixed to one of the spokes of the driving-wheel, and is worked by a strong lad. The return-wheel, E, 10 inches in diameter, is fixed to a drill-standard, and is set at the top-end of the face in the same way as the driving-wheel (Figs. 1 and 2, Plate X.).

The Mickley conveyor has been used in a district which had been worked on the longwall system, with a face 300 feet long, with 10 gateways each 30 feet wide, and 10 workmen per shift (Figs. 3 and 4, Plate X.). Height was made in the main road or winning gateway, A, by taking up a bottom-canch, 4 feet thick and 5 feet wide, and in the other gateways, the bottom-canch was taken up $2\frac{1}{2}$ feet thick and 5 feet wide. Cross-headings, B and C, were driven at intervals of about 150 feet; and a putting-station or flat, D, was made, between alternate headings, in the winning-place. The coals were brought from the face to the flat by hand-putters, and from the flat to the engine-plane-landing by ponies.

This longwall-face is now being worked by two conveyors: the driving-wheel of No. 1 conveyor being placed in the winning

gateway, and that of No. 2 conveyor midway between the winning gateway and the return-airway (Figs. 5 and 6, Plate X.). As this longwall is being driven by the side of an old goaf, height is made in a place, E, driven near the goaf-edge, in continuation of the tenth gateway, by taking up a thin canch. This place is used as a return-airway and as a second road out of the face.

The winning places, A and B, for each conveyor, are driven 24 feet wide, and about 9 feet in front of the face traversed by the conveyor. A bottom-canch is taken up 4 feet thick and 10 feet wide, close to the left-hand side. The right-hand side of each place is closely packed to within 3 feet of the face; the left-hand side is also packed, but the wall has to be kept back, so as to allow room for the men to work and for the passage of the conveyor. The bottom-stone being taken up in front of the conveyor-face, there is room for one tub to stand in front of the tub that is being filled from the conveyor, and the man working in the winning place can fill into this tub direct. Two roads are laid up to the face, and ponies bring in the empty tubs and take out the full ones. There is ample room for the stand of the driving-wheel, and for the lad to work the conveyor (Figs. 1 and 2, Plate X.).

The rails are laid along the face for the conveyor, about 2 feet from the coal, and this leaves sufficient room for the setting of the necessary timber. On the goaf-side of the rails, the roof is supported by two rows of chocks made of soft wood, 20 inches long, 5 inches wide and 2½ inches thick, set on a few inches of dirt. These chocks are set alternately, 8 feet apart, with props between them. When the rails are moved forward, as the face advances, another row of chocks is put in, and the back row is drawn out. Where it is necessary, crowntrees are put across the conveyor-way. The face of each conveyor advances about 3½ feet per day, and the way is shifted forward on alternate nights.

Three men do all the work in connection with the shifting-forward of the two conveyors: they shift the way, fix the wheel-stands, put on the rope, set new chocks and draw all back chocks and props in a shift of 8 hours, and these men are kept regularly employed in attending to two conveyors.

Since these conveyors were started, the width of the face has been increased from 300 to 360 feet, making 156 feet of face for

each conveyor and 24 feet for each winning place; and 12 men are now working, in place of 10 men per shift.

The best output from 360 feet of face, with 1 boy employed at No. 1 conveyor and 2 boys at No. 2 conveyor, has been 983 tons in one fortnight. The coal works much better, and the output has increased from 2·73 to 4·75 tons per man per shift.

The men in each face where the conveyors are used divide their earnings equally: this has considerably facilitated the work, and little time is taken up in filling the conveyor, as 2 men fill into it at the same time. The men prefer this method of working, for the coal has not to be cast as in ordinary gateways, the tub being stopped just where it is required.

The arrangement has been in use for several months, and five conveyors are working at the present time.

Under the ordinary conditions of longwall working, the putting, stone-work and shift-work cost 1s. 2d. per ton, including 16¼ per cent.; and under the new method of working with the conveyor, the stone-work, shift-work, chock-drawing and conveying cost about 6d. per ton, including 16¼ per cent.

Mr. C. H. Merivale asked what was the size of coal carried by the conveyor. He had visited the seam, where the conveyor was employed, and he had an impression that the coal was in small pieces, nothing larger than the size of one's fist. A similar tub had been tried at Newbrough colliery, and considerable difficulty was experienced, as the coal, although easily put into the tub, was extremely difficult to get out again: in that case, the pieces weighed from 1 to 2 cwts.

Mr. F. R. Simpson asked how far the main gateway had been carried, and whether any great expense was incurred in bringing up the second canch. The main gateway was very wide, and it would be interesting to know the expense under that head.

Mr. F. O. Kirkup said that at Garesfield colliery, one Blackett conveyor and two Bates conveyors were at work. He thought that there was ample work for both of these conveyors in collieries and mines, under suitable conditions.

Mr. J. English asked whether the 983 tons, stated to have been conveyed in one fortnight, was the product from one or two

conveyors. If from two, it was about 45 tons per day of, say, 9 hours, or 5 tons per hour.

Mr. C. H. MERIVALE asked whether the 983 tons per fortnight had been obtained when the conveyor was running from 6 a.m. to 5 p.m., and with one or two shifts of boys.

Mr. M. FORD asked what length of double way was kept in the gateways, and whether any difficulty was experienced in supporting the roof in the gateways, which were very wide. He also asked what was the thickness of cover at the point where the conveyors were working, that is, the depth from the surface.

Mr. T. E. FORSTER asked whether two conveyors had been tried running coals into the same main gateway, one on each side, as possibly there might be some difficulty in keeping two conveyors working on to the same main road. So far as the conveyor itself was concerned, he was not quite satisfied as to its capacity. A somewhat similar system, with small tubs running along the face, had previously been tried, but the output had not been satisfactory.

Mr. J. W. BATEY said that no difficulty had been experienced in getting large coal out of the tub-conveyor, the great difficulty had been to get the coal into the tub, as the height between the tub and the roof was sometimes rather low. The doors in the bottom of the tub were about 3 feet wide and 2 feet 8 inches long. The face had been continued for a distance of about 450 feet, and very little trouble had been experienced in keeping the roads open. When the road was advanced, a length of double way was laid at the face, sufficient to hold, say, 12 tubs, and then single way was laid farther back; and any stone taken down to make height was packed upon the side of the road, so as to support the roof. The quantity of 983 tons had been run by two conveyors in one fortnight. The coal-face dipped towards each conveyor at the rate of about ½ inch to the yard; the coals were coming from the high side down the bank to the conveyor in each case; and if the conveyors were placed on the low side, to put out the coal, more power would be required.

Mr. T. E. FORSTER asked whether there was any difference in the cost of timbering.

Mr. J. W. BATEY said that the cost of chock-wood was about 1d. per ton, and of the props less than ½d. per ton.

The CHAIRMAN (Mr. J. H. Merivale), in moving a vote of thanks to Mr. J. W. Batey for his interesting paper, congratulated Mr. Bates on his successful attempt to modify and alter an old system of conveying coal along the face so as to fit it for modern requirements. Mr. Bates' conveyor was really an old system of bringing coal along the face in small tubs, a method that he remembered seeing some 30 years ago at the Bedminster collieries, Bristol; and, with electric power, it had been introduced at a new colliery in Yorkshire. Mr. Bates had taken up an old obsolete system, and made it into a modern practical arrangement. The working of thin seams with coal-cutters and the use of conveyors, by diminishing the number of gateways, would considerably reduce the enormous expense of shift-work.

Mr. A. L. STEAVENSON seconded the vote of thanks, which was cordially adopted.

Mr. J. H. PIFFAUT's paper on "The Use of Cement-concrete in the Working of Thick Coal-seams" was read as follows:—

THE USE OF CEMENT-CONCRETE IN THE WORKING OF THICK COAL-SEAMS.*

By JOSEPH HIPPOLYTE PIFFAUT.

Water-transport of packing material† seems likely to provide engineers engaged in the difficult working of thick seams with an effective means of avoiding falls and the fires to which they give rise. Its application will probably become general, and will necessarily bring about a radical change in the methods of working hitherto followed in France.

Nevertheless, it is probable that this system of packing will not be everywhere applicable; and there are many cases in which present methods must still be adopted, especially that which consists in removing the deposit in horizontal layers, one by one, in descending order. The chief inconvenience of this method of working lies in the difficulty of supporting the packing, which forms the roof of the working-places. This difficulty is unimportant, when the packing material is somewhat clayey, particularly when it is possible to wait long enough before working beneath it, and the pressure to which it is subjected makes it thoroughly compact. These conditions cannot always be realized, and one is often obliged to leave, beneath the packing, a greater or lesser thickness of coal, which is lost. Attempts have been made to prepare beforehand on the floor of the working-place, timbering intended to form the roof of the next layer that is to be removed. This process, both expensive and difficult, does not appear to have given the anticipated result.

For three years past, another method has been in use in the Perrecy collieries, and it has facilitated, in certain cases, the

* "L'Emploi du Béton pour faciliter l'Exploitation des Couches Puissantes," *Comptes Rendus Mensuels des Réunions de la Société de l'Industrie Minérale*, 1904, page 326.

† "Water-packing of Seams," by Messrs Karl Müller and — Hussmann, *Trans. Inst. M. E.*, 1903, vol. xxvii., page 722; and "A Method of Packing Excavations in Coal-seams by Means of Water," by Mr. E. O. Forster Brown, *Ibid.*, 1904, vol. xxviii., page 325.

system of downward working. This process consists in covering the floor of each working-place with a layer of concrete, which becomes in its turn the roof of the underlying working-place.

The cement-concrete consists of a mixture of hydraulic lime from Beffes with slag or furnace-ashes, in the proportion of 2 cwts. of lime to 1 cubic yard of slag or ashes. The latter is used without previous screening, merely crushing any lumps larger than an egg in size. The mixing of the material is carried out at the surface by hand, but it is obvious that, if the cement-concrete be used on a large scale, the use of a pug-mill would reduce the cost, and would produce a more homogeneous and resistant cement-concrete for the same weight of lime. It is probable, moreover, if the cement-concrete be used in dry working-places, that a " fat lime " might with advantage be substituted for the hydraulic lime.

The floor, *a*, of the working-place, which is to receive the cement-concrete, is removed to about 12 inches below the floor of the gallery, so that sleepers and rails may be placed over the concrete. On this floor, a layer of coal-dust, 1 to 1½ inches thick, is spread; then a layer of cement-concrete, *b*, 8 to 10 inches thick; and lastly, packing in small pieces, *c*, about 8 to 10 inches thick; and then packing, *d*, in the ordinary way can be immediately proceeded with. The cement-concrete is rammed. It is spread in belts, *b*, parallel to the face over the whole available surface of the working-place; each band ends at a slope, formed by means of a plank held inclined at an angle of 45 degrees at a suitable point, against which the concrete is rammed. This slope is ultimately covered by the cement-concrete of the next belt, so that all the belts are bound together (Figs. 1 and 2, Plate XI.).

The trials carried out at Perrecy collieries have so far been made in three dry horizontal slices in a district of the mine, taken successively in descending order. The timbering was not removed. The interval of time between the deposition of a bed of cement-concrete, at a given point, and the moment of its uncovering in the lower working-place had been very variable; but in most cases it did not exceed two or three months. By way of experiment a working-place, 50 feet wide, was opened out beneath the bed of cement-concrete, which had been laid one

month only, and wagonways had often cement-concrete roofs, still more recent. In all cases, the results have been satisfactory.

The cement-concrete had set as completely as if it had been used for building a wall on the surface. It formed a roof to the working-place, and required for its support no more timber or lagging than if the roof had been formed by a bed of coal or shale of ordinary hardness. The cement-concrete was but rarely fissured round the base of timbers in the upper working-place, probably only round such as had in breaking become greatly inclined. The fissures were unimportant, and required no special attention.

As a comparative indication of the strength of the roof of the working-places, the following is the detail of the timbering in the working-places: fir-crowntrees, 13 feet long and 3½ to 4 inches in diameter at the small end, are each supported by 4 fir-props, 4 to 5 inches in mean diameter. The crowntrees are set parallel, and are spaced about 3 feet apart. The lagging consists of flat bars of oak, ¾ inch to 1¼ inches thick and 2 to 2½ inches wide; they are spaced 1 to 2 feet apart.

No falls had occurred, although some roadways made in the packing, without timbering, except that of the working-places served by them, which remained open for three or four months, had their height reduced from 1½ to 2 feet owing to the settling of the packing, which contained too little coarse rock. In consequence of this settling, the cement-concrete had become fissured, but the timbering and lagging were sufficient to sustain it.

As had been already mentioned, the cement-concrete was sandwiched between a thin layer of coal-dust and one of fine packing. The object of this packing is to prevent large stones from dropping directly upon the cement-concrete and breaking it. This precaution is probably not indispensable, but, as it cost nothing, it was desirable that it should be adopted.

The little layer of coal-dust prevented the cement-concrete from adhering to the solid coal. It formed, at the roof of the working-place, a good parting, which facilitated the working of the coal, while preventing any fragment of cement-concrete from being torn away with the coal. The dust-layer also allowed of a more perfect lower surface being given to the cement-concrete,

since it filled all the depressions of the floor, levelled roughly by pick-work; and when, in its turn, it became the roof of the lower working-place, it facilitated the placing of the timber-lagging, which could easily be introduced between the solid coal and the cement-concrete by slightly lowering the layer of dust. The coal-dust becomes intimately mixed with the coal of the working-place overlain by it.

In conclusion, the cement-concrete has yielded at Perrecy colliery the results which were desired. Owing to its adoption, it has been found possible to pass very soon and without any difficulty beneath any masses of packing, without this packing breaking down or crumbling and deteriorating the broken coal, and this, too, without in any case having left any thin coal as a roof.

These results were obtained in dry working-places; they would probably have been the same in wet places, for cement-concrete made with hydraulic lime, such as was used, sets rapidly in wet foundations. If the water-feeders in the workings were large it would be necessary to cease taking up the bottom coal in the removal of the pillars, the roadways could only receive the cement-concrete before being packed, and the union of the new cement-concrete masses with those placed earlier would require special precautions.

The increased cost of packing, due to the use of cement-concrete, is calculated as follows, taking the cost of hydraulic cement at 16s. 8d. per ton at the mine. For 1 cubic yard of cement-concrete: 2 cwts. of hydraulic cement at 16s. 8d. per ton, 1s. 8d.; labour, preparing the cement-concrete and loading it into wagons, 4d.; together, 2s. The cost of carriage and unloading in the working-places is not taken into account, since they are the same for cement-concrete as for ordinary packing. Assuming that cement-concrete is used everywhere of the maximum proposed thickness, say 9 inches, 4 square yards of floor will be covered with 1 cubic yard of cement-concrete; the cost will consequently be 6d. per square yard, to which must be added 1d. for labour in ramming, say, altogether 7d. per square yard.

In working-places, similar to those in which the trials have been made, yielding 3·2 tons of coal per square yard, the use of cement-concrete, therefore, adds about 2¼d. per ton of coal

extracted. In most cases, this extra cost will be largely compensated by the reduced cost of the timbering and lagging used in the working-places, and the rapidity with which the coal can be extracted enables further savings to be effected in the cost of maintaining the roadways and inclined planes of the working district.

The use of concrete, therefore, renders the method of working by successive horizontal slices, both easy and profitable.

Mr. A. L. STEAVENSON asked what was the thickness of the seam in which this method of working was adopted; also the thickness taken out at each level, the depth from the surface, and the system of working. It seemed to him that these false roofs would give way under the weight of the goaf.

Mr. T. E. FORSTER said that he had not seen coal-seams worked in horizontal slices, but he had seen ironore-deposits worked in slices, without the use of concrete.

Mr. W. C. BLACKETT remarked that he did not know whether most to envy a seam that would permit an extravagance of the kind described, or to be glad that he had not to overcome such difficulties. It was obvious in this district that cement-concrete could not be produced at the low price mentioned in the paper; where it was stated that the use of the concrete added 2¼d. per ton to the cost of the coal extracted. This appeared to be based upon a square yard of cement-concrete, 9 inches thick, only costing 7d. He did not think it possible for anybody in Great Britain to place cement-concrete underground for that cost.

Prof. H. LOUIS said that the system had been applied to one of the thick inclined seams, customarily worked in horizontal slices. In a vertical height of 24 feet, three slices would be formed, each 8 feet high; the seam being highly inclined, the roof and floor of the places would consist in all cases of coal; and as soon as the coal in one slice was wrought, it would be replaced by stone brought from the surface, and run into position from an upper level. The author's estimate of 7d. per cubic yard did not include the cost of the stowing; the author assumed that the stone-packing would have to be used in any case, and he simply added the cost of making a part of it into cement-concrete,

Mr. W. C. Blackett said that the price of 16s. 8d. per ton of cement was about one-half of what was paid for it in this country.

Mr. J. H. Piffaut (Génelard, Saône-et-Loire, France) wrote that the use of cement-concrete had been tried at the Perrecy collieries in order to complete and perfect the system of working by successive horizontal slices, worked in descending order. The seam has a dip of 30 degrees, and its width, measured horizontally, varies from 30 to 70 feet. The height of the slices, determined by local conditions, is 7·6 feet. The working-places are packed thoroughly, the cement-concrete forming only a very small portion of the packing (6 to 8 inches). Its sole object is to constitute for the working-places below, an artificial roof, separating it from the ordinary loose packing. Assuredly this roof is a somewhat flimsy one, but if it be supported by very simple timbering, it will more than suffice to prevent the crashing-down of the packing which overlies it, even if the packing itself be deficient in cohesion.

In his (Mr. Piffaut's) notes on this experimental utilization of cement-concrete, the cost-price stated therein did not include ordinary packing: it covered simply and solely the additional expenditure involved by the use of cement-concrete. This expenditure has been reckoned on the basis that hydraulic cement costs 16s. 8d. per ton, the average price current in France. It is evident, if this expenditure be calculated in the terms of a ton of coal, that it will diminish in proportion as the height of the slice increases. It would be very interesting to set against the expenditure involved in the use of cement-concrete, the profits which thereby accrue, but these can hardly be estimated beforehand, and so he (Mr. Piffaut) must be content to lay stress on the principal benefit derived from the use of the material: namely, that it facilitates the application of the system of working by horizontal slices in descending order. Here it would be first of all necessary to demonstrate the superiority of that system to all others used in the working of thick coal-seams. Generalizations on this point are, however, somewhat hazardous; for the selection of any particular system of working must depend on a great number of conditions which vary from one mine to the next.

It will suffice to mention that in taking the slices, one by one, in descending order, the difficulties are avoided which almost invariably happen when working by successive horizontal slices, in ascending order. In the latter case, the settling of the packing of the worked-out portions tends to cause dislocation of the mass of coal which remains to be taken in the upper slices. Hence, a reduction in the market-value of the coal, and, what is far more serious, a tendency to frequent fires. Moreover, in the highest slice, the roof consists of the packing of the preceding portion, and as this also has been dislocated by the settling of the packing of the lower slices, it becomes very difficult to keep it in place without an elaborate system of timbering.

At first it would seem that this last disadvantage would occur in the case of each slice on the descending system, even if cement-concrete were used. Such is not, however, the case: the settling applies only to a thickness of packing equal to the height of a single slice, and is consequently of little importance. Moreover, it takes place but slowly, and begins only some considerable time after the coal has been removed, and the packing has been completed. The working-places are not in the least affected thereby, and the upkeep of the roadways which have to be preserved amid the packing, presents no difficulty whatever.

The CHAIRMAN (Mr. J. H. Merivale) said that the probable method of working had been described by Prof. Louis, the slices being worked in descending order, about 8 feet high. He could quite understand, under such circumstances, that the use of cement-concrete might prove economical. The cost of the packing would be about 1s. per ton. The circumstances in this district were entirely different, and he did not think that cement-concrete could be used to advantage. He had pleasure in moving a vote of thanks to Mr. Piffaut for his interesting paper.

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

Mr. R. DODDS' "Note on the Composition of Coal from the Faröe Islands," and Mr. R. R. THOMPSON'S "Note on the Calorific Effect of Coal from the Faröe Islands," were read as follows;—

NOTE ON THE COMPOSITION OF COAL FROM THE FARÖE ISLANDS.*

By R. DODDS, A.Sc.

The sample of coal examined was received from Mr. G. A. Greener. The proximate analysis gave the following results:—

Moisture	12·30
Volatile matter	33·07
Fixed carbon	50·02
Ash	4·61

These results, when calculated for a dried sample, give:—

Volatile matter	37·71
Fixed carbon	57·03
Ash	5·26
Total sulphur	1·22

The determination of carbon, hydrogen, nitrogen and oxygen (by difference) gave for ash-free and dried coal:—

Carbon	67·71
Hydrogen	4·04
Nitrogen	2·65
Sulphur	1·46
Oxygen, difference	24·14

NOTE ON THE CALORIFIC EFFECT OF COAL FROM THE FARÖE ISLANDS.

By R. R. THOMPSON.

The determinations were made with the Lewis-Thompson calorimeter, yielding, as a mean of three separate experiments, an evaporative effect equivalent to 9·64 pounds of water per pound of coal.

* "The Coal-fields of the Faröe Islands," by Mr. G. A. Greener, *Trans. Inst. M. E.*, 1904, vol. xxvii., page 331.

Prof. P. P. Bedson (Armstrong College, Newcastle-upon-Tyne) explained the formula proposed by Mr. Goutal for calculating the calorific effect of a fuel from its proximate analysis: a method possessing considerable advantages over the older method usually employed, which required an ultimate analysis of the coal, thus involving somewhat lengthy operations. According to Mr. Goutal's formula, the calorific effect was equal to $82 \times C + aV$: V, being the volatile matter; a, a number obtained by calculation from the volatile matter in the ash-freed and dried coal; and C, the fixed carbon. The volatile matter for the ash-freed and dried coal, or V^1, being calculated in the following manner, as $C + V : 100 :: V : V^1$; and therefore $V^1 = (100 \times V)/(C + V)$. Mr. Goutal gave a series of values for a, corresponding to differing values of V^1, namely:—

$V^1 =$ 5, 10, 15, 20, 25, 30, 35, 40.
$a =$ 145, 130, 117, 109, 103, 98, 94, 80.

He (Prof. Bedson) had applied this formula to several coals, some of those, for instance, taken from the paper read before this Institute by Prof. H. Louis on "The Composition of Certain British Coals";* and one example would suffice to show the value of the rule, and the use that could be made of it. Taking Denaby Main coal, the experimental calorific effect was 8,200, calculated from the ultimate analysis by the ordinary rule, which assumed that the oxygen was all combined with the hydrogen, and gave a net calculation of the calorific effect of 8,145 calories. The proximate analysis, which was also given in the paper of Prof. Louis, gave a calorific effect, applying Mr. Goutal's rule, of 8,118, so that the difference between the two methods in this case was only 1 per cent. The members would understand the great difference in the time required to arrive at the ultimate analysis of the coal and that needed for the determination of the proximate composition. The value of the rule was such that it would commend itself to those who took an interest in matters of this kind.

Mr. W. C. Blackett asked whether Prof. Bedson found the theoretical calorific effect of any coal to be of much practical value. He had had calorific values ascertained, and in one

* *North of England Institute of Mining and Mechanical Engineers, Annual Report, etc., 1901-1902*, 1902, page lxxix.

instance, results equal to the best Welsh steam-coal were shewn where the coal tested could not be induced to burn.

Mr. A. L. STEAVENSON said that an evaporative effect equivalent to 9·64 pounds of water per pound of coal was a fairly good result, and he wanted to know how it had been obtained. Had it been merely ascertained that the coal contained or produced a certain number of British thermal units of heat; and, if so, could Dr. Bedson tell the members what was the value of such thermal units in actual practice?

Prof. P. P. BEDSON said that the calorific effect was the total heat given out in the process of the combustion of a substance. The calorific power of a substance might be high, and yet by reason of its low inflammability, the substance would be of little or no value as a fuel to be burnt under a boiler. Inflammability was, however, another question, and depended largely on the amount of volatile matter. Although a substance might have a high calorific value as a heat-giving power, it might be a poor fuel, from the difficulty with which it took fire and burned.

The CHAIRMAN (Mr. J. H. Merivale), in moving a vote of thanks to Mr. R. Dodds and to Mr. R. R. Thompson, said that both of these gentlemen were students at the Armstrong College, and the results of their labour had been placed at the service of the members, through the kindness of Prof. P. P. Bedson.

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

The following "Note on a Natural Paraffin found in the Ladysmith Pit, Whitehaven Collieries," by Mr. R. DODDS, was read as follows:—

NOTE ON A NATURAL PARAFFIN FOUND IN THE LADYSMITH PIT, WHITEHAVEN COLLIERIES.

By R. DODDS, A.Sc.

The subject of this note is a solid paraffin, which was discovered as an exudation in a drift of the Ladysmith pit, Whitehaven collieries.

The substance, as found, is a dark brown semi-solid material, not unlike vaseline in consistency. It emits an odour resembling that of paraffin-oil, and has a disagreeable taste like that of a lubricating-oil. It is entirely combustible, contains no mineral matter, and consists wholly of a mixture of hydrocarbons of the paraffin series.

By distillation under reduced pressure, namely a pressure of 70 millimetres, it was fractionated into four separate portions. The first portion, distilling over between 90° and 180° Cent., is a colourless liquid possessing a paraffin-like odour and having a specific gravity of 0·777 at 17° Cent. This represents about 37·5 per cent. of the total. The second portion is a slightly-coloured liquid, distilling over between 180° and 240° Cent. This represents 17·5 per cent. of the whole. The third portion, representing 25 per cent. of the mixture, was collected between 240° and 300° Cent., and is obtained as a pale yellow solid, which melts about 35° Cent. and from it, by crystallizing from petroleum-ether, a white crystalline solid, melting at 48° to 51° Cent., is produced. The fourth portion, the residue left in the retort, constituting some 20 per cent. of the mixture, is a dark, fusible solid.

With the object of obtaining a further clue as to the nature of the constituent hydrocarbons, the first and second portions were then mixed and submitted to careful fractional distillation under reduced pressure. In this manner, nine fractions were obtained, the first five being colourless liquids, the sixth and seventh having a slightly yellow colour, the eighth being a yellow

liquid solidifying at 9° Cent., whilst the ninth fraction was a semi-transparent solid. The specific gravities and the refractive indices of each liquid fraction have been determined, and with their aid the proportion of carbon and of hydrogen in each has been approximately ascertained.

Although the material at disposal was not sufficient to permit of the isolation of individual hydrocarbons present, from the specific gravities and the refractive indices it is evident that the lowest member of the paraffin hydrocarbons present is that containing 10 carbon atoms in the molecule, namely decane, $C_{10}H_{22}$, and from the melting point of the solid paraffin mentioned above, it seems evident that a hydrocarbon of the formula $C_{24}H_{50}$ is contained in this paraffin.

It should be mentioned that the materials have been tested for sulphur, a not infrequent constituent of native petroleums, and that traces only have been discovered in some of the more volatile portions.

Mr. A. L. Steavenson asked whether the solid paraffin, in the Whitehaven collieries, was found in samples, or in pounds or in tons; and in what strata it was found. In Scotland, paraffin was found in shale, and probably the sample described in the paper was of similar occurrence. In order to produce the wax, there had no doubt been a whin-dyke or intrusion of basalt, and the heat had driven off the wax just as if the shale had been placed in a heating kiln.

Mr. R. W. Moore (Whitehaven) wrote that about 250 gallons of the substance pronounced to be a natural paraffin, had been yielded by the stone-drift driven from the Ladysmith pit: but the supply had now practically ceased. The drift was set away from the shaft (which had passed, in succession, through Permian strata, the Whitehaven Sandstone and Coal-measures) at the depth of 1,065 feet from the surface, in what are evidently the Yoredale rocks, the top of which was found at about 358 feet below the Main Band coal-seam. The drift had been driven nearly level in a south-westerly course, towards St. Bees Head, in the direction of the dip, and had intersected the Main Band coal-seam, over a large downthrow west fault, at a distance of 3,900 feet from the Ladysmith shaft. Throughout that distance,

the Main Band coal-seam had been wrought, into pillars, overhead; and in those workings no whin-dyke or basaltic intrusion, in any form, had been encountered. Indeed, the West Cumberland coal-field, so far as at present known, does not furnish even a single instance either of a whin-dyke or of naturally-coked coal.

At a distance of 750 feet from the Ladysmith shaft, the drift passed from the Yoredale rocks into the Coal-measures; and, at 2,370 feet from the shaft, the natural paraffin was first encountered. It was found oozing from the base of a bed of white post, about 30 feet thick, overlying a coal-seam, 15 inches thick, which had been cut through in the drift. On exposure to the atmosphere, the liquid became viscid, and eventually quite stiff. The application of a very gentle heat speedily restored the substance to the liquid state. This semi-solidification retarded the flow of the paraffin; but, during the continuation of the drift for a distance of at least 300 feet, as new ground was cut, similar exudation took place from the freshly exposed surfaces.

The Main Band coal-seam is about 300 feet above, and the Yoredale rocks are about 58 feet below, the drift where the paraffin was found. It would be interesting to know whether this natural paraffin has any commercial value.

Mr. Henry M. James (Whitehaven collieries) wrote that, in the drift, the oil or paraffin, over a distance of about 450 feet, exudes sometimes from shale and sometimes from sandstone. There can be no great quantity, as the pressure is not able to overcome the consolidation of the wax, which takes place as soon as it comes into contact with the air of the drift; the flow of oil ceasing immediately on this taking place. No whinstone is known to occur in the neighbourhood of the drift, which lies entirely below the workable Coal-measures of that part of the Cumberland coal-field: it is, however, subject to intrusions of limestone.

Mr. A. L. Steavenson said he understood that there was no whin there in the neighbourhood of the Ladysmith shaft, but it was possible that there might be an intrusive bed of whin in the Coal-measures, unknown to those who were working the coal.

Prof. P. P. Bedson understood that about 250 gallons of the paraffin had been found. From his (Prof. Bedson's) point of

view, he had not had sufficient of the material to determine the nature of the hydrocarbons entering into its composition. He had not considered the question of its origin; no doubt the wax had probably been formed by distillation of some material—coal or shale, but as to how this distillation had taken place he did not venture to make any suggestion.

The CHAIRMAN (Mr. J. H. Merivale), in moving a vote of thanks to Mr. R. Dodds for his interesting note, said that the members were privileged in having, at the Armstrong College, some 20 or 30 gentlemen, who placed their valuable services at the disposal of the Institute, and to none were they more indebted than to Prof. Bedson. He had given them a large number of papers from time to time, and they were obliged to him for his great courtesy and kindness in taking up any subject which they brought before him.

Mr. A. L. STEAVENSON seconded the vote of thanks, which was cordially approved.

Mr. R. R. THOMPSON'S "Note on the Composition of Dover Coal" was read as follows:—

NOTE ON THE COMPOSITION OF DOVER COAL.

By R. R. THOMPSON.

The sample of coal was received from Mr. F. W. North. The proximate analysis gave the following results:—

Moisture	0·60
Volatile matter	26·87
Fixed carbon	66·54
Ash	5·99
Total sulphur	1·33

The coal burns with a long smoky flame, and yields a firm coke and a brick-red ash.

The calorific effect determined in the Lewis-Thompson calorimeter gave, as the average of two experiments, an evaporative effect equivalent to 12·65 pounds of water per pound of coal.

Mr. F. W. North (London, E.C.) wrote that, acting in his capacity as consulting engineer for the Consolidated Kent Collieries Corporation, Limited, he had had great pleasure in submitting the specimen of coal, and had carefully examined the analysis made by Mr. R. R. Thompson. This analysis corroborated the estimate that he had formed of its value.

The interest that this specimen created was no doubt due to the fact that it was part of the first block of coal that had been taken out from the coal-field in the county of Kent, and it might be assumed to represent fairly the character of the coal that might be expected from the seams that were known to lie beneath it. The members would observe that the coal was of a very friable nature, and in that respect corresponded with many of the coals worked in the Pas-de-Calais coal-field, as well as many other parts of the Continent, where it was frequently necessary to manufacture 30 or 40 per cent. of the entire output into briquettes for locomotive purposes, etc.

It appeared to be impossible, at present, to correlate this particular coal-seam with any one of the numerous coal-seams worked in the Pas-de-Calais; and, therefore, he was unable to indicate whether this coal-seam belonged either to the Upper or to the Lower series of the Coal-measures so well known on the southern side of the Straits of Dover. Its thickness was about 20 inches,

and it was very satisfactory to know that it lay nearly horizontal, from which it might be inferred that the seams beneath would also lie nearly level. This coal-seam, 20 inches thick, was passed through at a depth of 1,273 feet; but a seam, not of good quality, had previously been proved at a depth of 1,180 feet. These seams were separated from each other by about 90 feet of hard sandstone, with streaks of coal, and some thin beds of shale.

It was at present impossible to form an opinion as to whether the coal-field had been denuded before the deposition of the newer overlying strata, but it was quite reasonable to assume that considerable denudation might have taken place. This question, however, would be set at rest when the seams found at Dover could be properly correlated with those of the Pas-de-Calais coal-field. Only 30 feet of Coal-measures now existed between the first and uppermost coal-seam and the thin beds of limestone representing the Lias, about 25 feet thick, which, at this point, lie directly upon the Coal-measures without any intervening strata at a depth of 1,150 feet from the surface. As is well known, the shaft commenced at the surface in Chalk about 170 feet thick, succeeded by Gault, the Hastings Beds, etc.

Although he (Mr. North) had referred to the quality of the coal and had submitted a sample, it was impossible for him to suggest that the seam was of any commercial value, because, in his opinion, it lay too near the column of Kind-Chaudron tubbing, 1,200 feet in height, that had been required to tub off the overlying aqueous strata. A foundation for this tubbing was found in the Coal-measures at a depth of 1,173 feet, and as the roof of this coal-seam was entirely composed of hard sandstone it was possible, whenever any extensive subsidence took place from the working of this seam, that a break would occur up to the overlying aqueous strata.

The CHAIRMAN (Mr. J. H. Merivale), in moving a vote of thanks to Mr. R. R. Thompson for his analysis and determination of the calorific value of the coal from the Dover colliery, stated that the members were also indebted to Mr. F. W. North for supplying the samples, exhibited that day, and for his interesting description of the occurrence of the second coal-seam in the Dover sinking.

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.

GENERAL MEETING,

HELD IN THE WOOD MEMORIAL HALL, NEWCASTLE-UPON-TYNE, JUNE 10TH, 1905.

MR. T. W. BENSON, PRESIDENT, IN THE CHAIR.

The SECRETARY read the Minutes of the last General Meeting, and reported the proceedings of the Council at their meetings on May 20th and that day.

The SECRETARY read the balloting list for the election of officers for the year 1905-1906.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. PHILIP ALLAN, General Manager of Gypsum-mines, Quarry and Mills, 1, Marlborough Gardens, Stanwix, Carlisle.

Mr. CHARLES WORTHINGTON COMSTOCK, Civil and Mining Engineer, Boston Building, Denver, Colorado, United States of America.

Mr. HARRY DEAN, Mining and Metallurgical Engineer, Armstrong College, Newcastle-upon-Tyne.

Mr. JOHN ROBINSON FELTON, Colliery Manager, West Stanley Colliery, Stanley, R.S.O., County Durham.

Mr. HENRY STUART FLEMING, Consulting Engineer, 1, Broadway, New York City, United States of America.

Mr. CHARLES HANBURY HEARN, Engineer, Power-station, Natal Government Railways, Durban, Natal, South Africa.

Mr. HUGH JOHNSTONE, H.M. Inspector of Mines, 8, Church Street, Durham.

Mr. JOSEPH FREDERICK MENZIES, Engineer, General Superintendent, North-western Improvement Company, Roslyn, Washington, United States of America.

Associate Members—

Mr. William Chrystal, Lace Diamond-mine, Kroonstad, Orange River, Colony, South Africa.

Mr. Charles Henry de Rusett, Warden House, Tynemouth, Northumberland.

Associate—

Mr. John Neil Grey, Mining Student, 20, St. Mary's Terrace, Ryton, R.S.O., County Durham.

Students—

Mr. Norman Henry John Liddell, Mining Student, Grange Road, Ryton, R.S.O., County Durham.

Mr. Joseph Simpson, Mining Student, Wheatley Hill Colliery Office, Thornley, R.S.O., County Durham

Mr. Charles Osborn Wraith, Mining Student, Thornley Colliery Office, Thornley, R.S.O., County Durham.

Mr. H. Lawrence read the following paper on "An Improved Watering-tub for laying Dust in Coal-mines":—

AN IMPROVED WATERING-TUB FOR LAYING DUST IN COAL-MINES.

By HENRY LAWRENCE.

The method of fitting pumps or other apparatus into watering-tubs for wetting or damping the dust in coal-mines is not new. About 12 years ago, the writer made a model tub, and fitted the inside with a pump, copper-pipes, etc. The pipes were laid round the top edges of the tub, so arranged that the water could be discharged at either end, at either side separately, or all round simultaneously. The pipes in the model were not fitted with jets, only small holes being drilled in the pipe, at a slight angle and some distance apart. The writer is of opinion that the jets in the full-sized tub should be made as fine as possible, so as to deliver the water in the shape of a fine mist. The watering-tub should be attached at the back of the set of tubs, so as to mix the water-spray with the fine dust and air of the mine. The tub would be made of the same dimensions as those used in the mine; and, if it did not hold sufficient water, one or more tubs containing water only could be attached next to the watering-tub, and connected to it by means of elastic pipes. The writer used a Comet pump, because it had no valves; and, as the speed would require to be altered to suit the various kinds of traction used in different mines, and because he used a rotary and not a reciprocating motion, he adopted gearing.

He has found that a mixture of whitewash and alum, where there was much woodwork, decreased its inflammability and delayed its ignition; and he suggested that an occasional mixture of alum and water passed through the sprinkler would effect the same purpose.

Two tubs, fitted with this appliance in March, 1897, had been used in mines with satisfactory results.

Mr. A. L. STEAVENSON contended that prevention was better than cure, and if they could prevent the dust from accumulating, it was better than any remedy for damping it. About 6 years ago, a paper was read by Mr. R. Harle* describing an invention for damping the coal on the top of the tubs as they passed outbye from the station or landing. The dust was thus prevented from rising and coating the sides of the engine-plane: he suggested that this was a better arrangement than that described by Mr. Lawrence.

The CHAIRMAN (Mr. J. H. Merivale) moved a vote of thanks to Mr. H. Lawrence for his paper

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

Mr. M. F. HOLLIDAY's paper on "An Outbreak of Fire, and its Cause, at Littleburn Colliery," was read as follows:—

* *Trans. Inst. M. E.*, 1899, vol. xviii., page 113.

AN OUTBREAK OF FIRE, AND ITS CAUSE, AT LITTLEBURN COLLIERY.

By M. F. HOLLIDAY.

At 7·30 p.m. on Thursday, May 11th, 1905, the night-banksman at Littleburn colliery smelt fire, and on inspection it was discovered to be proceeding from the bottom of the hole of the elevator-bucket. This hole is sunk about 16 feet below the level of the ground. The fire-hose was applied, and prevented what most certainly would have been a disastrous fire; the outbreak having been detected in time, the damage was slight.

After careful enquiry, it was found that the fire was caused by the thoughtlessness of a labourer laying an electric lamp of 16 candlepower on a heap of fine coal-dust. This dust, from the Busty coal-seam, is very fine and almost like quicksilver. This elevator-hole is cleaned out every night after the pit has finished drawing coal, that is, about 4·10 p.m.; and the hole being 16 feet deep, a length of loose cable was kept to lower an electric lamp into the hole, so as to give light to the man working in it. The man on this occasion, not thinking that there could be any danger, laid down the lamp at the back of the hole, on the coal-dust, and when he had finished, after 15 minutes' work, came out, drawing up the lamp, with the result that 3 hours later, smoke was seen arising from the hole.

As this was suspected to be the cause of the fire, experiments were made to establish the fact.

Experiment I.—A shovelful of fine coal-dust was taken, and an electric lamp of 16 candlepower was laid among the dust, slightly covering the lamp. In 3 minutes, after switching on the current, smoke began to arise, and 8 minutes later the bulb of the lamp exploded on account of the intense heat that was generated. This coal was put on one side so that developments might be watched, and 3 hours later the coal was a mass of dull-red fire.

Experiment II.—A pailful of coal-dust was gathered from the vicinity of the elevator, and an 110 volts electric lamp of 16 candlepower was laid loosely on the top of the coal-dust, but it was not covered up as in the previous case. In 8 minutes, after the current had been switched on, smoke began to rise freely, and in 25 minutes, from the time that the current was switched on, the heat was so intense as to melt the glass globe. The pail was set on one side, and 3 hours from the time that the lamp was removed from the pail the heat was so intense as to set fire to a piece of wood, 1 inch thick, and on the stem of a pyrometer being placed in the pail it registered 150° Fahr.

Mr. S. F. Walker (Bath) wrote that the experiments made upon the ignition of coal-dust at Littleburn appeared to him to be of considerable importance from two points of view, that of the heat delivered by an incandescent electric lamp, and the accumulation of heat in heaps of coal at mines. It had long been realized by electricians that the incandescent lamp produced a considerable quantity of heat, although in the early days of electric lighting, it was the fashion to say that it did not give off any appreciable heat. When the Savoy Theatre was first lighted by incandescent lamps, the manager used to appear before the curtain at the commencement of the performance, and solemnly break a lamp in a mass of flimsy gauze, shewing that the breaking of the lamp did not ignite the gauzy material. It was difficult, indeed, to ignite any substance by breaking an incandescent lamp in its neighbourhood, but it was a very different matter when the lamp was allowed to remain near any inflammable substance for some time. Many serious accidents had taken place where incandescent lamps had been left burning in the neighbourhood of inflammable material. The celluloid lamp-shades, that were sold a few years ago, were the cause of several fires. A little consideration would show that accidents of the kind were only to be expected. Of the heat generated by the electric current in its passage through the carbon filament, only 3 per cent., by the latest determination, was converted into light, and even that must be reconverted into heat after doing its duty as light; and every lamp of 16 candle-power was, therefore, delivering heat at the rate of nearly 3½

British thermal units per minute. Taking the specific heat of coal at 0·377, this would mean that 1 pound of coal in the immediate neighbourhood of the lamp, if it absorbed all the heat delivered by the lamp, would have its temperature raised about 9° Fahr. per minute. Thermal calculations were always difficult, because it was always difficult to get all the factors into the equation, but the above calculation proved that where a lamp was placed, as at Littleburn, either in the hole where the fire took place, or in a pail of coal-dust, the heat liberated would raise its temperature sufficiently to give rise to the phenomena detailed. There would probably also be secondary action in the coal-dust, giving rise to further generation of heat.

The second point was more important, and he suggested that the experiments be carried further, and that the temperatures be observed at each stage, under various conditions, where smoke comes away, etc. It appeared to him that valuable information would be obtained, as to the action which ensued where spontaneous combustion took place underground. He would also suggest that some experiment should be made with carbonic acid gas. Having obtained certain conditions, say, where smoke was coming away, where dull red heat was present, and where the mass of coal was in flame, the mass should be exposed to the action of carbonic acid gas, in the gaseous form (but under compression), and also in the liquid form, and the results noted. Cylinders, holding the gas under compression, could be obtained of all sizes, some small enough to put in the waistcoat-pocket, and of sufficient strength to do so without danger, fitted with graduated delivery-cocks, enabling the gas to be liberated at any rate desired. He believed that a careful series of experiments made on the above lines would yield valuable information.

Mr. A. L. Steavenson said that Mr. Holliday's paper directed attention to two important points, namely, dust and the danger from electric wires. It was terrible to contemplate what might happen if a heapstead took fire, with perhaps 200 or 300 men below. On one occasion, some 47 men were underground at Pagebank colliery when the shaft was on fire. It was a bratticed shaft, and there was no other road out. How the fire originated was not known, but it was suggested that a lamp set the wood brattice on fire. He had little doubt now that it was caused by the spontaneous ignition of fine dust descending the downcast

shaft, and settling on the brattice. The danger of dust was not known in those days, and all sorts of things were blamed. He (Mr. Steavenson) did not object to the use of electricity: in fact, he used it very extensively in some of the largest mines in Cleveland, but the mineral wrought was a stone, which would not burn, and there was no explosive dust. Further, in the mines where he used electricity, there were other roads to the surface, about 2 miles away in all cases, so that if a heapstead, or any part of the wagonway, got on fire, the men could walk out by another way. This paper now brought before the members another source of danger, which had not been previously recognized. He had always attributed the risk of danger from electricity to a short circuit in the wires, but Mr. Holliday described how an incandescent lamp in good order had produced fire. If this had occurred at some other time of the day, there might have been 500 men in the pit; and a serious accident might have followed.

Prof. Henry Louis enquired whether there was not an error with regard to the observed temperature in the coal-dust of 150° Fahr. He did not think that wood could take fire at that temperature.

Mr. Holliday explained that the stem of the thermometer was embedded in the coal-dust, considerably below the glowing fire, and, consequently, it did not register the full heat.

Mr. W. C. Blackett said that he did not think that the result from this particular lamp was entirely unexpected, or one that they had not a right to anticipate. In his experience of these bulbs for some years, he found that they would char almost any combustible material with which they were left long enough in contact. Everything depended on the length of time during which they were left in contact. They could handle a lighted bulb, but it could not be held very long in the hand. Similarly, they could touch for a short time a hot piece of iron, although they could not handle it for long. It was the length of time during which a given state of heat was in contact with the combustible substance that caused its destruction. With regard to the settling dust, which was feared by Mr. Steavenson, that which settled on lamps was harmless, as it did so slowly and was carbonized gradually. If they examined the dust, which had

accumulated on an electric lamp, they would find that it was not in anything like the same state as that in which it was originally deposited.

Mr. A. L. Steavenson proposed a vote of thanks to Mr. Holliday for his interesting paper.

The President (Mr. T. W. Benson), in seconding the vote of thanks, said that the occurrence described by Mr. Holliday only shewed how very careful everyone must be nowadays, so as to steer clear of the accidents that might happen at any time at the best-managed mines.

The vote of thanks was cordially adopted.

Mr. Donald M. D. Stuart's paper on "The Development of Explosives for Coal-mines" was read as follows:—

THE DEVELOPMENT OF EXPLOSIVES FOR COAL-MINES.

By DONALD M. D. STUART.

When considering a subject in which the results of experiment and experience have come into conflict, it is useful to recall its past history and trace the sources of disagreement, in order to profit by the teachings of experience; and this is true in an important sense of mining explosives, which affect the best interests of the greatest industry in the kingdom.

Some thirty years ago, gunpowder was without a rival in coal-mining and had enjoyed this position in the previous two centuries. It had proved to be so simple and effective a blasting agent, that the necessity for other substances did not arise; but new explosives were now discovered, and brought into prominence by the Report of the Select Committee upon Explosive Substances appointed by the House of Commons in 1874, and from that time onward the subject has been under constant investigation. These new or modern explosives have claimed the attention of successive Royal Commissions and Mining Institutions. The Royal Commission appointed to inquire into Accidents in Mines, 1879; the Flameless Explosives Committee appointed by The North of England Institute of Mining and Mechanical Engineers, 1888; and the Royal Commission on Explosions from Coal-dust in Mines, 1891, devoted years to the investigation of the subject. The transactions of the Mining Institutions record constant observation and research, and the Departmental Committee appointed, in 1896, by the Principal Secretary of State for the Home Department, to inquire into the Testing of Explosives for Use in Coal-mines, has for the last eight years carried out continuous tests by firing the new explosives in inflammable gaseous mixtures, so as to ascertain which could be fired as blown-out shots without igniting the mixture. These investigations have led to the production of numerous explosives and the development of gunpowder to a high standard of safety and efficiency.

This evolution arose from the facts that colliery explosions were sometimes caused by blasting, and that in the coal-dust pervading many coal-mines there lay a peril which could be awakened into terrible activity by fire-damp ignited at a shot, and even by the shot itself. The ideal explosive was therefore suggested to be one that, while possessing efficient blasting action, would not ignite fire-damp, nor distil and ignite the educts of coal-dust.

The first stage in the evolution was the introduction of nitro-explosives represented by dynamite, lithofracteur, gun-cotton and other substances that exploded with a rapidity enormously in excess of gunpowder. According to Mr. Is. Trauzl, whose researches were adopted by the Prussian Fire-damp Commission of 1881, a cartridge of grain-gunpowder, 13 inches long, required 0·03 second for complete ignition, but only 0·000,6 second was needed to explode a similar cartridge of dynamite. Mr. Trauzl also reported that a grain of confined gunpowder burned off at a speed of 10 millimetres (0·394 inch) per second, with a transmission of the flame from grain to grain of 10 metres (32·80 feet) per second; but unconfined charges of gun-cotton and dynamite detonated with a velocity of 16,500 to 19,500 feet per second.* With these results, the Prussian Commission reported that the enormous rapidity of explosion of high explosives, constituted a fundamental element of safety, reducing the peril of ignition of fire-damp or coal-dust to a minimum, not to say vanishing point; and concluded that the lightning-like rapidity of explosion went far towards limiting, if not excluding, the possibility of ignition of fire-damp by blasting.†

The idea of safety in rapidity of explosion, was a development of Sir Humphrey Davy's researches, in which he found that fire-damp differed materially in combustibility from common inflammable gases, and required exposure to an ignition-temperature for an appreciable time in order to effect its explosion. The question was examined by the French Commission on the Use of Explosives in the Presence of Fire-damp in Mines, and Messrs. E. Mallard and H. Le Chatelier described the phenomenon as " re-

* "Report of the Prussian Fire-damp Commission," translated by Dr. P. Phillips Bedson and Mr. L. L. Belinfante, *Trans. Inst. M.E.*, 1893, vol. iv., page 672.

† *Ibid.*, page 672.

tardation of ignition."* When a mixture of fire-damp and air was raised to a temperature of 1,202° Fahr. (650° Cent.) it was reported that the retardation may amount to 10 seconds; and as the gases of high explosives were produced at an exalted pressure, they would expand and cool below the ignition-point of fire-damp in some thousandths of a second, or a minute fraction of the period of gaseous contact essential to ignition.†

The Royal Commission appointed to Inquire into Accidents in Mines carried out independent investigations, and reported in 1886 that dynamite, gelatine-dynamite, cottonpowder, tonite and potentite would prevent colliery explosions, even by blown-out shots in explosive gaseous atmospheres containing inflammable coal-dust, provided that they were fired in water-cartridges; which, the Royal Commissioners observed, could be done cheaply, simply and without restriction.‡

TABLE I.—COLLIERY EXPLOSIONS.

Date.	Colliery.	Explosive Used.
1878	Wester Gartshore	Dynamite
1882	London and South Wales	Dynamite
1884	Naval	Dynamite
1887	National	Gelatine-dynamite, with water-cartridge
1889	Hebburn	Roburite and gelignite
1890	Shelton	Tonite
	Holly Lane	Tonite
	Thorncliffe	Roburite
1891	Apedale	Gelignite, with water-cartridge
1894	Albion	Gelatine-dynamite
1896	Tylorstown	Ammonite

The conclusions of the Prussian, French and British Commissions were not confirmed by practice, and many colliery explosions occurred where high explosives were adopted, both with and without the water-cartridge, some of which are recorded in Table I.

These explosions disclosed the fact that there was a fundamental difference between the conditions of the experiments made for the Commissioners, and the conditions prevalent in the mines; in the former, the explosives proved incapable of causing ex-

* *Report of the French Commission on the Use of Explosives in the Presence of Fire-damp in Mines*, translated by Messrs. W. J. Bird and M. Walton Brown, 1890, page 21.

† *Ibid.*

‡ *Final Report*, 1886, page 60.

plosions of fire-damp or coal-dust, and in the latter they caused explosions of both. This difference in conditions had evidently eluded observation, and collieries that had not suffered explosions by shot-firing for long periods of years while using gunpowder, were now the scenes of explosions while using high explosives substituted with the advice that they would more certainly sustain the record.

The disturbing factors that permitted such contrary results to arise between experimental results and practical work, were not adequately considered; and great efforts were made to fasten attention upon the flame of explosives, as the source of gaseous and coal-dust ignitions. The Prussian and British Commissions attached much importance to the presence of flame in a fired explosive, as an indication of danger; and the phrase, "flameless explosive" was adopted to introduce the nitrate-of-ammonium compounds. An explosive that did not yield flame, was claimed to be innocuous, even if fired in the presence of fire-damp or coal-dust. Both phrase and claim were important, and awakened great interest, insomuch that in 1888 The North of England Institute of Mining and Mechanical Engineers appointed the "Flameless Explosives Committee" to investigate them. The Committee arranged their experiments to approximate in a measure to the conditions of practical blasting, in angling the line of fire to the axis of the gas-tube, thereby interfering with the velocity at which the products of the explosives were projected through the gaseous mixture; and by means of sight-holes in the side of the gas-tube, direct observations were made of the condition of the products as they issued from the mouth of the cannon and passed through the gaseous mixture. The Committee carried on their investigation for some years, and reported that the high explosives, ammonite, ardeer-powder, bellite, carbonite, roburite and securite produced evident flame, and that the flame from blown-out shots was not prevented by the quantity or length of the stemming.

The phrase, "flameless explosive" having proved to be untenable, the supporters of these explosives rechristened them "safety explosives," and under this title their substitution for gunpowder was vigorously pressed upon owner, agent and manager of mines, in blue books, papers to Mining Institutes,

and journals of the coal-trade, with the assurance that they were the panacea for colliery explosions. The substitution was adopted to but a fractional extent, as in the predominant judgment of owner, agent and manager, gunpowder was the safest, all round and most efficient explosive; and they continued to use it.

The claims of the "safety explosives" were laid before the Royal Commission on Explosions from Coal-dust in Mines, with an appalling list of explosions alleged to have been caused by gunpowder-shots, and the results of some experiments made with "safety explosives" and gunpowder, which were claimed to prove that explosions and blasting accidents would almost entirely disappear if gunpowder were prohibited and "safety explosives" compulsorily substituted. The Royal Commissioners, however, reported that several high explosives "may be practically safe for all purposes,"* but declined to recommend the universal prohibition of gunpowder, and advised that where its use may be open to question, the Secretary of State for the Home Department should direct certain precautions to be adopted.

The mining industry was not largely influenced by the experiments made with the "safety explosives," nor by the claims made for them; long experience with high-grade gunpowder left no doubt that, in practical hands, it was the safest and best explosive; and the "safety explosives" made very little progress. Two years later a Coal-mines Regulation Bill was introduced in the House of Commons, and section 1 gave power to make Special Rules for explosives in the manner laid down in sections 51 to 53 of the Coal-mines Regulation Act of 1887; that is to say, in conference with owner, agent and manager, with right of appeal to arbitration in which the arbitrator should be a practical mining engineer, or a person accustomed to the working of mines. The Bill was passed, and it was expected that the subject of explosives would be dealt with under section 1. Early in December, 1896, the Secretary of State appointed a "Committee to Inquire into the best Tests to Determine the Safety of Explosives in Coal-mines, and as to the means to be adopted

* *Second Report of the Royal Commission on Explosions from Coal-dust in Mines*, 1894, page xxviii.

by the Home Office for applying such tests for the purposes of Special Rules to be proposed by the Secretary of State under section 1 of the Coal-mines Regulation Act, 1896, or of Orders to be issued by him under section 6 thereof." (It will be remembered that section 6 empowered the Secretary of State to prohibit or regulate the employment of explosives which he considered were, or were likely to become, dangerous.) A week or two later, the mining industry were surprised to find that the Secretary of State intended to deal with the subject with the absolute authority given to him in section 6, and not to permit the consultative reference to the industry and appeal to a mining tribunal as laid down in the principal Act, and directed in section 1. An Order dated December 19th, 1896, was issued under section 6, directing the compulsory use of certain high or "safety explosives" and disallowing the use of gunpowder in certain mines after July 1st, 1897, but universally after January 1st, 1898, although the Royal Commission had declined to recommend such action. The settlement of the subject by Special Rules under section 1, as indicated in the warrant appointing the Committee was therefore almost immediately abandoned.

In the practical judgment of the industry, the Explosives Order was injurious to its safety and best interests, and investigation showed that this judgment was sustained by evidence of fact. By reference to official records of explosions and blasting accidents, it was found that the appalling list of calamities alleged to have been caused by gunpowder-shots, and submitted to the Royal Commission upon Explosions from Coal-dust in Mines, was incorrect. This list indicated that 2,449 lives had been lost in explosions caused by gunpowder in the years 1873 to 1892, whereas 664 was the number attributed to gunpowder in the blue books after admitting doubtful cases; while 84 that were charged against gunpowder were actually caused by the high and "safety-explosives." Moreover in the ten years, 1887 to 1896, the explosions due to gunpowder (including very doubtful cases) caused 179 deaths, while 411 deaths were caused by high or "safety-explosives;" although they were used in probably less than 5 per cent. of the shots, there being evidence that not less than 95 per cent. of the shots in the ten years were charged with gunpowder. It was not surprising that the industry rose *en masse*, and opposed the Explosives Order by memorial or deputation to the Secretary of State from every district, insomuch that it was withdrawn, and another

of June 4th, 1897, issued, deferring any change until January 1st, 1898, with limited application to mines generally defined as dangerous by virtue of showing gas in quantity indicative of danger in the previous three months, and by virtue of containing dry coal-dust; but, in the great majority of mines, leaving the subject of gunpowder to the experience and judgment of owner, agent and manager.

The selection of explosives for mines that were considered to come under the definitions of gaseous and dusty in the Explosives Order, was committed to the Explosives Committee, who erected a testing apparatus at Woolwich for ascertaining the action of explosives when fired through gaseous and dusty mixtures.* The apparatus differed from the installation adopted by the Committee of The North of England Institute of Mining and Mechanical Engineers, in that the tube was a fraction less than two-thirds of the diameter and one-fourth of the length, and there were no sight-holes. The Woolwich apparatus, therefore, allowed the products of the explosives to be projected centrally through the short length of inflammable gas without any interference with their velocity; consequently, the explosive that developed the highest muzzle-velocity allowed the shortest period of contact between its products and the inflammable gas, and passed the test most successfully. In these circumstances, most of the high explosives projected their products through the inflammable gas without igniting it, while the products of gunpowder with low velocity caused ignitions.

The test established a line between explosives that did or did not ignite the gas in the given conditions, but gave no indication of their positions, whether near or distant from the dividing-line. A modification in the stemming, however, proved that high-grade gunpowder was near to the line, and that it would not ignite the gas when damp stemming was substituted for the dry powder used in the test; in fact "the lowest grade of common blasting gunpowder can frequently be fired without igniting the gas, if it is stemmed well with puddled wet clay of a good stiff consistency"; † and as such wet stiff clay is ordinarily used in practical mining, the difference between gunpowder and permitted explosives in

* *Trans. Inst. M. E.*, 1897, vol. xiii., page 612.

† *Twenty-fourth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1899*, page 119.

liability to ignite gas in mines as determined by the test, was obviously of somewhat academical value. Further still, the physical form of the explosive, and the wrapper enclosing it were found to be necessary elements in passing the test, as it was "conclusively shown . . . that an alteration in the wrapper, or in the physical form of an explosive, may materially alter its behaviour in an inflammable atmosphere."* Finally, the test-charges of gunpowder were practically three times heavier than the charges of high explosives, but equal lengths of stemming were fixed for all alike, contrary to practical shot-firing. The different results obtained with dry and wet stemming, and variations in the physical condition and wrapper of permitted explosives (inevitable in most of the high explosives that passed the test), and the disproportionate charges with equal lengths of stemming, show that the difference between gunpowder and high explosives disclosed by the test, depended upon artificial conditions opposed to mining practice. The light which experience in practical shot-firing has thrown upon the results of the test, will be seen later on.

A large number of explosives were developed for the Woolwich test; no less than 58 substances were submitted, 32 of which passed and were placed on the Permitted List. A new trouble now arose with the permitted nitrate-of-ammonium and nitro-glycerine explosives in the detonator required to fire them, which caused serious accidents both in and out of the mines; some finding their way to the screens and markets, sometimes even to private houses, where they exploded with injurious effect calling for heavy compensation, and prejudiced the explosives. The Explosives Order was therefore extended so as to prohibit the use of detonators, unless they were kept in a locked case separate from any other explosive, and under the control of the owner, agent or manager, or some person specially appointed in writing, and used only by persons specially authorized in writing; thus increasing the compulsory precautions in using permitted explosives.

Shortly afterwards, and before the Permitted List had been in force for a couple of years, a memorandum was issued from the Home Office as follows:—

* *Twenty-fourth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1899*, page 47.

The Secretary of State finds from the reports made to him by H.M. inspectors of mines that there is a desire on the part of mine-owners for further assistance in the selection of explosives for use in dangerous mines than is given by the present "Permitted List." That list contains merely the names of all the permitted explosives, *i.e.*, the explosives which have passed the Woolwich test. It is left to mine-owners to select the best explosive from the list, which does not distinguish in any way between those which have barely passed the test and those which can be fired safely under much more severe conditions. The ultimate responsibility of selecting from the list the safest explosives and the best suited to their requirements must always remain with the mine-owners; but, in order to assist them in this matter, the Secretary of State has decided to establish a new test, the conditions of which will be more stringent than those of the present test, particularly in the following points:—The charges of the explosive to be fired will be larger. They will be fired in a more sensitive gaseous mixture. The required number of shots must be fired without any ignition of the gas.*

The test-charges to be fired under the new conditions were:—†

High explosives:	10 shots with charge equivalent to 3 ounces of dynamite, and 9 inches of stemming.
	10 shots with charge equivalent to 4 ounces of dynamite, and 12 inches of stemming.
Gunpowder:	10 shots with charge equivalent to 9 ounces R.F.G.[2] gunpowder, and 9 inches of stemming.
	10 shots with charge equivalent to 12 ounces R.F.G.[2] gunpowder, and 12 inches of stemming.

The first list of permitted explosives, under the new or Special Test, was embodied in the Explosives Order of September 24th, 1900, and comprized: ammonite, amvis, carbonite, electronite, ardeer-powder and roburite; but the number soon multiplied and up to the end of 1903, 97 explosives had been submitted for test or re-test. The Permitted List of February, 1905, contains 45 explosives—practically 50 per cent. more than the original list superseded by the Special Test; and the owner, agent or manager has to discriminate in this larger list. Like the original test, the Special Test does not distinguish between those which have barely passed the test and those which can be fired under more severe conditions, with one exception. Representations were made to the Secretary of State that bobbinite yielded sparks and so-called flame, and samples were taken at Burradon colliery, for re-test at Woolwich testing station. In the re-test, 10½ ounces of the bobbinite (slightly greater than the

* *Twenty-fourth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1899*, page 116.

† *Ibid.*, page 118.

heavier charge of the special test) with 12 inches of stemming were fired from a vertical gun at night, and gave off sparks, with (in some instances) a faint red glow. Corresponding charges were then fired in the tube filled with the test-mixture of inflammable gas, both from the sample taken at Burradon colliery and from a remnant of the bobbinite used in the special test some twelve months previously; but neither would ignite the gas. The shots with corresponding charges of bobbinite were then repeated from the vertical gun at night, and into the special test-mixture of inflammable gas, but with only 6 inches of stemming—one half the quantity allowed in the Special Test; and in these very severe conditions, although the appearance of sparks and glow was more pronounced, neither the sample from Burradon colliery, nor the remnant from the Special Test, would ignite the gas.* The results were reported with the conclusion that, "bobbinite is not at the bottom of this list as regards safety."† This re-test has shown that one of the permitted explosives can be safely fired under much more severe conditions than the Special Test, and so long as the others have not been submitted to this newer test, and until they have passed it, bobbinite must remain as the only permitted explosive that has been safely fired under conditions of increased severity, while retaining its original efficiency and economy as a blasting agent.

The Special Test has, however, disclosed the fact that explosives can be made to pass any such test as that appointed by the Explosives Committee, but generally by sacrifice of simplicity in composition, and efficiency in blasting action: elements of safety not recognized by the test. It is not suggested that the enterprize and genius of manufacturers and their technical staff in developing explosives should be interfered with, but manufacturers and colliery managers could be saved from unnecessary danger and anxiety besides waste in expenditure, if this enterprize and genius were relieved of the limited sphere of the Woolwich test, to develop simple and efficient blasting agents instead of the numerous complicated substances that by means of the Special Test occupy positions on the Permitted List.

* *Twenty-eighth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1903*, page 140.

† *Memorandum on the Testing of Explosives for Coal-mines and on the Behaviour of the Explosive Bobbinite*, by Captain J. H. Thomson, H.M. Chief Inspector of Explosives, March, 1904, page 2.

Although all the permitted explosives are required to be made to the standard submitted to the Special Test, the composition of some of them is very difficult to determine. Dr. A. Dupré (chemical adviser to the Home Office) has drawn attention to this difficulty for several years. In 1901 he reported:—"Much work has, however, been done in order to keep analytical methods fairly abreast of requirements. This is a subject requiring more and more care and attention every year. The compositions of explosives generally are becoming more complicated, and this is especially the case with regard to explosives permitted to be used in mines, and, at the same time, in these explosives, the limits within which variations are allowed are drawn more and more narrowly. The correct analysis of explosives thus becomes increasingly more difficult, and at the same time of greater and greater importance. Some of the explosives contain as many as eight constituents, and their correct analysis is often a matter of some difficulty."*

Dr. A. Dupré returns to the question in his report for 1902, and says:—"I have continued to devote considerable time to the working-out of improved methods of analysis, which, especially as regards permitted explosives, becomes more and more complicated, while, at the same time, the importance of having a reliable check on the composition of such explosives increases."†

In his last-published report, Dr. Dupré again says:—"We still have had to devote a considerable amount of time to the working-out of improved methods of analysis of explosives, which are constantly increasing in number and complexity."‡

There is evidently some reason to doubt whether the samples of these complicated explosives that pass the Special Test are or can be repeated in the manipulation of quantities for trade, and under effective chemical check. Such explosives cannot be regarded as a necessity for mines, as simple substances are available, that have passed the same test and one even more severe. In contrast with these complicated compounds

* *Twenty-sixth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1901*, page 23.

† *Twenty-seventh Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1902*, page 25.

‡ *Twenty-eighth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1903*, page 27.

there is gunpowder with its developments in elephant-cartridge, earthquake, bull-dog and bobbinite, which are simple mechanical mixtures, the qualities and quantities of which can be easily determined by wellknown methods of analysis, and which are perfectly stable until exploded in ordinary work. It is quite true that elephant-cartridge, earthquake and bull-dog are not on the present Permitted List; but, while the Special Test has deprived the mining industry of these three simple, safe and efficient blasting agents, it has substituted the complicated substances that have called up the repeated warning of Dr. A. Dupré, and cannot be conducive to the safety of gaseous and dusty mines.

The managers of mines who use permitted explosives have now to choose from the 45 substances on the Permitted List, and as it is impossible for them to determine the qualities by personal trials, they have to depend upon facts of experience derived from the records of mining. The records are in the annual reports of H.M. inspectors of mines, but unfortunately some of the reports do not give complete information; ignitions of gas and coal-dust are reported, but not the explosives used in the shots that caused them; and the blasting accidents are not always complete, requiring examination of the reports of H.M. inspectors of explosives for the facts; consequently, the preparation of tables of ignitions and accidents demands excessive time and labour. There is, however, adequate evidence to show the practical results of the old and new explosives in regard to safe mining.

It will be remembered that the Explosives Order came into operation on January 1st, 1898, so that up to December, 1903—the last records published at present—six years' experience of its practical effect in preventing colliery explosions are available; and, by placing the records of the antecedent period in juxtaposition, the results of the two periods may be seen at a glance. The records are set forth in Table II.

The Explosives Order hedged round the permitted explosives with precautions of great practical value, directing that the shots should be fired only by competent persons appointed in writing; still, during the six years that it has been in force, the number of fatal explosions is the same as in the antecedent period, but the non-fatal explosions nearly twofold greater.

The prevention of explosions was the primary purpose of the Explosives Order, and it was founded upon the assurance that the explosives, which it licensed for gaseous and dusty mines, would prevent explosions by shot-firing in the mines, where they were adopted. Both purpose and assurance have failed of accomplishment, and this has been somewhat obscured by the fact that the loss of life in explosions has greatly diminished, which has been claimed as a result of using permitted explosives. It is important to remove this dangerous misconception. When a charge of explosive has ignited gas or coal-dust in a mine, the potential peril of an explosion has been brought into activity; and the subsequent development or propagation, whether simply

TABLE II.—COLLIERY EXPLOSIONS DUE TO SHOT-FIRING.

Periods.	Number of Fatal Explosions.	Number of Non-fatal Explosions.	Total Explosions.
Six years antecedent to the Explosives Order, 1892-1897	16	29	45
Six years under the Explosives Order, 1898-1903	16	55	71
Increase in the period under the Explosives Order	0	26	26

local or extensive, is wholly independent of the explosive used. Every shot that has ignited gas or coal-dust in a mine has created the potential start of an explosion; and the result, whether fatal or non-fatal, depends upon conditions entirely distinct from the shot. Therefore, every ignition of gas or coal-dust by shot-firing has practically the same potential peril as regards the explosive *per se*; and the records show that this peril occurred 45 times in the six years 1892 to 1897, and 71 times in the six years 1898 to 1903.

There was, however, a considerable difference in the quantities of coal worked in the two periods under notice, and presumably a corresponding difference in the extent of blasting; so that, under ordinary circumstances, the ignitions of gas and coal-dust would be greater in one period than in the other. There are no complete records of the number of shots fired in the two periods, but probably the quantities of coal worked may be taken as a fair criterion, as six years would cover variations

and give a reasonable average. Upon this basis, the records are summarized in Table III.

TABLE III.—COLLIERY EXPLOSIONS AND COAL-OUTPUTS.

	Six Years antecedent to the Explosives Order, 1892-1897.	Six Years under the Explosives Order, 1898-1903.	Differences.
Coal raised ...	1,121,542,000 tons.	1,323,807,295 tons.	202,265,295 tons: an increase of 18 per cent.
Ignitions of fire-damp and coal-dust by shot-firing	45	71	26: an increase of 57 per cent.
Coal worked per ignition	24,923,155 tons.	18,645,032 tons.	6,278,123 tons: a decrease of 25 per cent.

The records, therefore, show in round figures 6,000,000 tons less per ignition of gas and coal-dust in the period from 1898 to 1903; and while the production increased 18 per cent., the ignitions increased 57 per cent.; in other words, the active perils of explosions by shot-firing largely increased during the time when the Explosives Order was in force, therefore the diminished loss of life must have been due to causes other than the explosive used, and the cause is not far to seek.

It is a wellknown fact that the mortalities in large explosions occur almost wholly in the paths of propagation, and only a minute fraction of life is lost at the point of origin. If explosions could be limited to the immediate vicinity of the shot: in other words, if propagation could be prevented, the terrible death-roll and destruction of property in large explosions would cease, and it is in this direction that the diminished loss of life has been won. The highest mortality in a single explosion in the period, 1898 to 1903, was 8 lives (the Llanbradach colliery explosion, 1901); but in the antecedent period of 1892 to 1897, 290 lives were lost in one calamity (the Albion colliery explosion, 1894). Both explosions were started by shots, one charged with carbo-gelatine, the other with gelatine-dynamite or gelignite; and the disparity in the loss of life, 290 to 8, was obviously not due to the explosives. Again, of the 400 lives lost in explosions from shot-firing in 1892 to 1897,

337 or 82 per cent. were caused by 3 explosions (the Albion, Tylorstown and Brancepeth colliery explosions) leaving 33 deaths by the remaining 13 explosions. This aspect of the question may be further illustrated by comparing the killed and wounded with the number of explosions in the two periods (Table IV.).

TABLE IV.—KILLED AND WOUNDED IN COLLIERY EXPLOSIONS.

	Six Years, 1892-1897.	Six Years, 1898-1903.	Differences.
Total persons killed and wounded in explosions due to shot-firing	481	175	Decrease 306, or 63 per cent.
Number of persons killed and wounded per explosion	10·68	2·46	Decrease 8·22, or 77 per cent.

The gratifying reduction of 63 per cent. in mortalities was therefore exceeded by the diminution of 77 per cent. in lives lost per explosion; in other words, the killed and wounded per explosion were reduced 77 per cent. by arrest of propagation, that is to say by conditions distinct from the shot, and wholly independent of the explosive used.

It will now be evident that the great reduction in mortalities in the period under the Explosives Order was not due to the explosives used, because as a fact the number of explosions by shot-firing greatly increased, but to the reduced loss of life per explosion. The suggestion that the reduced mortalities were due to the régime of the Explosives Order with its partial exclusion of gunpowder from mines, is therefore contrary to the facts; and while giving the permitted explosives a fictitious value and a dangerously misleading repute, deprives the executive administration of mines of the fruit of untold labour and sacrifice in seeking an understanding of the propagation of explosions, and how to prevent it. The diminished loss of life in 1898 to 1903, therefore, represents the results achieved by those associated in the management of mines, in preventing propagation of explosions.

The Explosives Order was founded also upon another assurance, that the adoption of permitted explosives would almost wholly prevent the accidents that had occurred in blasting in past years; and this assurance may now also be compared with the results of experience. In Table V., the

fatal and non-fatal accidents in blasting, recorded in the reports of H.M. inspectors of mines and explosives, during the régime of the permitted explosives, are placed in juxtaposition with those that occurred in the antecedent period, as these, it was assumed, would not be repeated.

TABLE V.—ACCIDENTS INCIDENT TO BLASTING.

Periods.	Fatal Accidents.	Non-fatal Accidents.
Six years, 1898 to 1903, with permitted explosives	140	1,139
Six years, 1892 to 1897, prior to the permitted explosives	114	873
Increases	26 or 22 per cent.	266 or 30 per cent.

The results recorded in Table V. are therefore contrary to the assurance, and this notwithstanding the supplementary practical precautions with which the Explosives Order safeguarded the use of the permitted explosives.

Whatever qualifications may be urged in palliation of these unfortunate retrograde results in ignitions of gas and coal-dust, and in blasting accidents, the substantial fact remains that in twelve years' experience, one half of the period with unrestricted use of gunpowder and the other half with compulsory use of permitted explosives in dangerous mines, the explosions and accidents were considerably less in the former than in the latter period. The assurances upon which the Explosives Order was founded, have not been fulfilled; on the contrary there has been a serious retrograde movement during its régime.

In the highest interests of the mining industry it must be repeated that this retrograde result was foreseen and foretold in 1897, and would have been avoided if the subject had been dealt with under section 1 of the Coal-mines Regulation Act, 1896; that is to say by Special Rules framed in the manner set out by the principal Act, in consultation with the owner, agent and manager, with right of appeal to a mining tribunal where their views differed from the requirements of the Home Office. The present position however has now to be dealt with, and it would be most useful for future guidance if the causes of the retrograde

results could be elucidated; but preliminary to this, certain valuable features of the Explosives Order should be referred to, because of the limited manner in which they have been applied.

The Explosives Order established two principles forming an important practical advance towards the prevention of colliery explosions by shot-firing, namely:—Standard composition and quality of explosives; and shot-firing by competent persons appointed in writing; which excluded the cheap inferior powder that had caused disaster, and ensured effective examination of working-places for gas and coal-dust before firing shots by fixing responsibility upon the shot-firer. The application of these principles was unfortunately limited to mines that had yielded gas in quantity indicative of danger in the preceding three months, and to the roads of dusty mines, and excluded from the faces and within 30 feet thereof of dusty and every part of non-gaseous mines; which allowed the continued use of inferior explosive without any control, check or precaution against their dangerous properties. It will be remembered that, early in 1897, the Gunpowder Trade Association memorialized the Secretary of State to apply the principle of standard composition and quality to gunpowder, so as to prohibit the use of standardless low-grade powder; and to allow only high-grade powder of authorized standard to be taken into any mine.

The difference between high-grade and low-grade gunpowder was referred to in 1897, in the reports upon the Woolwich testing station. After expressing an opinion that probably the highest-grade gunpowder would in combination with various tampings eventually secure a place on the Permitted List, the report continues:—"The difference, however, between the behaviour of the highest grade of gunpowder and blasting powder containing anything under 70 per cent. of saltpetre, even when well 'milled,' is most remarkable."*

The proposal of the Gunpowder Trade Association that gunpowder used in coal-mines should be of this highest grade and to authorized standard, was not accepted by the Home Office, consequently for the last seven years the door has been left open for gunpowder of unknown composition and quality, of irresponsible or foreign make, and in its cheapness necessarily dangerous in

* *Twenty-second Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1897*, page 141.

the presence of fire-damp or coal-dust, to be used in all mines except those in which gas in quantity indicative of danger had been found in the previous three months. The character of this low-grade powder and the protection secured against it in gaseous mines, is also referred to in the report of the Woolwich testing station in the following terms:—"The cheap and dangerous rubbish used in some parts of the country and flattered by the name of blasting-powder may, so far as this [permitted] list is concerned, be at once consigned to a well-deserved oblivion."*

Although the responsible gunpowder-manufacturers would not make, nor managers knowingly purchase such low-grade powder, it is the practice in some districts for the miners to purchase their explosive at local shops where there are no means of discriminating the quality of the substance; and where the price per pound is a dominant consideration, so that low-grade powder may find its way into mines. Moreover, this low-grade powder appears to have been available so recently as 1903, when a serious accident occurred at a mill where it was made.†

Already, at least two colliery explosions in non-gaseous mines have been traced to low-grade powder; and surely the time has arrived when the Secretary of State might remove the limitation which he has placed on section 6 of the Coal-mines Regulation Act, 1896, and direct the adoption of high-grade powder of authorized standard in all mines where gunpowder is used; and also consign the cheap and dangerous powder to oblivion, not only as regards gaseous mines, but every coal-mine. If a Supplemental Order were made touching all coal-mines other than those within the scope of the present Explosives Order, permitting the use of a standard high-grade gunpowder only, with similar precautions to those enforced with permitted explosives, an important advance would be made towards the prevention of explosions and blasting accidents in such mines; and it will scarcely be suggested that life and property in these mines are worthy of less protecttion from obvious danger than is considered necessary for the mines controlled by the Explosives Order.

* *Twenty-second Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1897*, page 141.

† *Report (No. CLIX.) to the Right Honourable the Secretary of State for the Home Department on the Circumstances attending an Explosion which occurred in a Press House of the Factory of the Lowwood Gunpowder Company, at Lowwood, near Ulverston, Lancashire on the 12th March, 1903*, by Major A. Cooper-Key, 1903.

Coming to the causes of the increased number of explosions and blasting accidents, it will be remembered that the distinctive character of the permitted explosives was that in the Woolwich test they would not ignite a mixture of coal-gas and air much more inflammable than any gaseous mixture found in coal-mines; much less could they ignite a mixture of coal-dust and air, which was less sensitive to ignition than the gaseous mixture. In practical mining, however, the permitted explosives are found to ignite gaseous mixtures much less sensitive to ignition than the mixture in the Woolwich test. For example, typical explosives of nitrate-of-ammonium and nitro-glycerine compounds that passed the Special Test, have caused explosions of gas: amvis ignited gas at Pemberton colliery in 1900, burning two men, and again in the same colliery in 1902, killing two men and setting the workings on fire; while saxonite ignited fire-damp at Maypole colliery in 1902, setting the place on fire and burning five persons. Again, special bull-dog, which passed the Special Test, ignited gas at Rhosdhu colliery, killing one man and burning five others. The ignition by special bull-dog was in a coal-face intersected by numerous vertical hitches or faults giving off fire-damp; the hole containing the cartridge was actually bored to within a few inches of one of these faults, and burst into the gaseous fissure when fired; the ignitions by amvis and saxonite were in coal or strata in normal condition.

There was another explosion of important significance. Besides the general fact that coal-dust was less sensitive to ignition than the gaseous mixture at Woolwich, there were the experiments made for the Royal Commission on Explosions from Coal-dust in Mines in which charges of 24 ounces of gunpowder (whether high-grade or low-grade, does not appear), 10 ounces of ammonite and 8 ounces of roburite, with varied lengths of stemming, the heaviest charge (gunpowder) having the least, were fired at the bottom of a shaft into vertical columns of coal-dust and air. The gunpowder sometimes ignited the dust, but ammonite and roburite did not; and upon these experiments the Commission was advised that explosives like ammonite and roburite were incapable of igniting coal-dust; advice which was recorded in the final report.* Again in 1898, experiments were made at the Woolwich testing station, when

* *Second Report of the Royal Commission on Explosions from Coal-dust in Mines*, page xxv.

charges of permitted and non-permitted explosives were fired under heaps of anthracite and steam-coal dust, as well as from the cannon into coal-dust mixtures, with the result that the non-permitted explosive ignited the dust, producing flame, but the permitted explosive gave no appearance of flame.* Notwithstanding these experimental results, roburite which passed the Special Test, ignited coal-dust at Orrell colliery in 1901, causing an explosion that wrecked the colliery and killed the four men in the workings.

These disastrous contrasts between experimental results and practical experience, demonstrated elements of danger in the permitted explosives that were not discovered by the Woolwich test and require elucidation.

During the years 1894 and 1895, the author carried out protracted investigations of the initiation and propagation of colliery explosions, especially by shot-firing, the results of which were published; † and as they appear to throw some light upon the behaviour of the permitted explosives in practical mining, he ventures to refer to them. At this time, attention was concentrated upon the flame in the products of explosives, and it was urged with much vigour in some quarters, that this flame which was visible in gunpowder was the source of gaseous and coal-dust ignitions. The author's investigations did not support this view, and he offered a word of warning in the following words:—"The important point to be considered in the employment of explosives, is manifestly that element which constitutes their danger; and to confine attention to the presence or absence of visible flame upon their ignition, or of inflammable bodies in the products of their combustion, is to linger upon the fringe of the question."‡ The "Flameless Explosives Committee" of The North of England Institute of Mining and Mechanical Engineers observed flame in the products of the high explosives as already stated; but subsequently Mr. Alfred Siersch employed

* *Twenty-third Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1898*, page 133.

† *Coal-dust an Explosive Agent*, London, 1894; *The Origin and Rationale of Colliery Explosions*, Bristol, 1895; "The Phenomena of Colliery Explosions," *Trans. Inst. M. E.*, 1896, vol. xii., page 371; "The Chemistry of Colliery Explosions," *Proceedings of the Bristol Naturalists' Society: Physical Section*, 1897, vol. viii., page 109; and *Transactions of the American Institute of Mining Engineers*, 1894, vol. xxiv., page 905, and 1896, vol. xxvi., page 108.

‡ *The Origin and Rationale of Colliery Explosions*, London, 1895, page 123.

photography to obtain actual records of the flame, and gave the results to this Institution.* Still later, the author used photography to ascertain whether the permitted explosive bull-dog gave flame, and for this purpose he used charges in excess of that fixed for bull-dog in the permitted test, in both horizontal and vertical holes, in the faces of limestone-cliffs. Only one inch of stemming was used, and all the shots were blown out, with the camera fixed 8 feet laterally from the mouth of the holes. The Ross-Zeiss anastigmat-combination lens and Cadet lightning-plates were used, and bull-dog proved to be flameless; that is to say in the highest type of apparatus known in photographic optics, it did not yield flame of sufficient intensity to impress an image upon the plate; still bull-dog gave a faint glow (the shots were fired upon dark nights) to the naked eye.† This faint glow led to further investigation by Mr. Andrew F. Hargreaves,‡ who also found that bull-dog was flameless to the camera, and that the temperature of the faint glow was below 2,732° Fahr. (1,500° Cent.); the temperature which the French Commission on the Use of Explosives in the Presence of Fire-damp in Mines, decided to constitute a safe explosive for gaseous mines. Mr. Hargreaves noted that a visible flame was not necessarily the most dangerous in regard to temperature; he placed the temperature of the feebly-luminous Bunsen flame at 2,372° Fahr. (1,300° Cent.), while the luminous gas flame was much lower; and the practically-invisible flame of hydrogen exceeded 3,632° Fahr. (2,000° Cent.). It was now obvious that while the eye was fastened upon the visible flame of an explosive, supposing it to be the source of danger, there was concealed in the products an invisible flame of much more serious danger as regards temperature. The question, whether the visible flame in the products of low-grade blasting powder, the temperature of which was fixed by Sir F. A. Abel and Capt. A. Noble§ at 3,272° to 3,632° Fahr. (1,800° to 2,000° Cent.), will

* "Photography in the Technology of Explosives," by Mr. Alfred Siersch, *Trans. Inst. M. E.*, 1896, vol. xi., page 2.

† "Photographic Flame Tests of Explosives," by Mr. Donald M. D. Stuart, *The Colliery Manager*, 1900, vol. xvi., page 208.

‡ "An Investigation of the Flame of Explosives," by Mr. Andrew F. Hargreaves, *The Colliery Manager*, 1900, vol. xvi., page 560.

§ "Researches on Explosives: No. II.—Fired Gunpowder," by Capt. A. Noble and Sir F. A. Abel, *Philosophical Transactions of the Royal Society of London*, 1880, vol. clxxi., page 232.

ignite gas or coal-dust in mines more or less readily than the invisible flame in the products of roburite and saxonite, the temperatures of which are usually fixed at 3,812° to 5,432° Fahr. (2,100° to 3,000° Cent.), is a purely academical point. The practical fact is that these typical permitted explosives have ignited gas and coal-dust in mines; consequently, for practical purposes, their products are as dangerous as the products of gunpowder, though they are less luminous or even invisible. It is therefore obvious that visible flame is not an element in determining the safety of the present explosives.

In the same investigations, the author observed that gunpowder and high explosives produced different effects in inflammable mixtures, and arrived at certain conclusions which may be quoted here with the associated remarks; these were as follows:—

The essential danger in an explosive, is the heat-energy it develops; and if that energy could be wholly expended in the work of disintegrating the strata, no danger could arise from this cause; but in the nature of the case, it is practically impossible to adjust the charge of explosive to the exact demands of the work contemplated, and there is a surplus of energy in almost every shot that is fired . . . . The essence of the question is therefore the surplus heat, or if the shot be blown out, the total heat in the charge; and the danger is in this heat becoming available for distillation of the coal-dust . . . . In the high explosives, the heat-energy is developed with immense rapidity, ... In mining powder the combustion is slower, ... The heat-energy and products of combustion of mining powder have been determined by Sir Frederick A. Abel and Sir Andrew Noble; and similar determinations of nitro-glycerine have been made by Professor Berthelot . . . . Mining powder produces 48·65 per cent. of solid matter, including water, and 51·35 per cent. of gaseous products, of which 19·98 are combustible; and 1 gramme generates 516·8 units of heat: . . . . Nitro-glycerine yields wholly gaseous products, with the exception of water, but no combustible gases, and 1 gramme generates 1,600 of these units of heat. . . . . The important difference between mining powder and nitro-glycerine is not in the nature of their products, but in the quantities of heat they respectively generate, as, given equal charges of 12½ ounces of these explosives (the quantity in the shots at the Camerton and Timsbury collieries), the mining powder would yield 183,141 units of heat, while the nitro-glycerine would generate 567,000 units; and it is obvious that, when the surplus heat of the powder had been exhausted in vaporizing the moisture of the coal-dust, there would remain in the products of the nitro-glycerine an amount of heat-energy, representing more than twice the original amount in the powder, to institute distillatory action and cause disaster. . . . . To displace mining powder by a "high explosive," that generates a greater quantity of heat, is to increase the danger; . . . . In 1893, Mr. H. Hall, H.M. inspector of mines, made some experiments with coal-dust for the Royal Commission enquiring into the subject, by firing charges of explosive in a shaft, the air of which was heavily laden with coal-dust. . . . . When it is remembered that the cannon in which the charges of explosive were fired, was vertically suspended at the bottom of

the shaft: its axis corresponding with the axis of the shaft: it will be seen that the products of combustion were projected up the open pit, at the velocities due to the rapidity with which the heat was generated in the charges. . . . . The charge of mining powder undergoing slow combustion, propelled its products to a limited distance, at a velocity which permitted lateral expansion from the mouth of the cannon, and which allowed the heat to institute chemical actions in the suspended coal-dust; . . . . The roburite and ammonite undergoing detonation, propelled their products at a velocity greatly exceeding that of the mining powder, which necessarily disallowed of equal lateral expansion in the vicinity of the muzzle of the cannon, and which caused them to pierce through the dust-cloud to the much greater height, due to the larger initial velocity. The heat therefore passed through the coal-dust, with a rapidity, which would not permit chemical action to be initiated; and being diffused through a considerable height of the shaft, and consequently a much greater volume of dust-cloud, was dissipated, and the coal-dust was not ignited. The difference in the behaviour of these explosives, was therefore due to the great disparity in the volumes of dust-laden air, in which their products of combustion surrendered their heat. With mining powder, the velocity of propulsion from the cannon allowed the heat to be concentrated in a limited volume of dust-laden air, and its application to the particles of coal for a sufficient period to initiate chemical actions. With roburite and ammonite, the higher velocity of propulsion . . . . . diffused that heat through a much greater volume of dust-laden air, and did not permit contact with the particles of coal of the necessary duration to institute chemical actions, before the temperature of distillation was broken down. . . . . The shots in mines are fired at all inclinations, in small and tortuous tunnels, so that there is no unlimited open and free space, the axis of which corresponds with the axis of the shot-hole (like that provided by the vertical shaft), through which the products of combustion may be driven, until the dissipation of their heat is effected. . . . ; therefore the greater velocities of projection in the "high explosives" simply effect a more rapid propulsion of the products of combustion against the surrounding and opposing faces, be they the roof, floor, or side-walls; and the heat is concentrated in the coal-dust upon these faces. If that heat be adequate to vaporize the moisture present, and initiate chemical processes in the coal-dust; it is obvious that these processes will be instituted regardless of the velocities . . . . with which the heat is conveyed to that coal-dust. If charges of mining powder, roburite and ammonite, were fired as in ordinary mining operations, and in corresponding positions, so that their products of combustion were propelled against opposing surfaces in the vicinity of the shot-hole, and those products contained equal quantities of heat; identical effects upon the coal-dust upon these faces must follow. . . . . By the instantaneous generation of the heat-energy, which is a distinctive feature of "high explosives"; the ignition of coal-dust can probably be avoided if it be suspended in a vertical column of air immediately adjoining the surface-atmosphere; but if coal-dust be confined as it is in the contracted space of a road in a mine, the supposed safety due to the instantaneous generation of heat, and the consequent superior velocity of the movement of the vehicle of this heat, has no existence.*

At the same time, the author expressed these views in the discussion upon Prof. Vivian B. Lewes' paper upon "Mining

* *The Origin and Rationale of Colliery Explosions*, by Mr. Donald M. D. Stuart, Bristol, 1895, pages 123-128.

Explosives," and concluded with the words:—"The danger in explosives was the heat-energy at disposal after the disruptive effects were produced; and that this element, which was common to every explosive, was the factor to be investigated and considered, and constituted a danger, which was independent of the nature of the explosive, and to a very large extent of the products also."*

These investigations of 1894 and 1895, with the conclusions formed, are now of interest because of the behaviour of the permitted explosives in subsequent years, in causing explosions indistinguishable from those due to low-grade gunpowder, and failure to sustain the claim to safety. The claim was founded upon their supposed flamelessness, and this failing on test, upon practical flamelessness; which again failed upon discovery that their products contained invisible gases of higher temperature than the luminous gases producing flame. It was also claimed that their products were wholly gaseous and free from combustible matter, forming two elements of safety compared with gunpowder; but these elements have not availed to prevent explosions. Again, instant resolution of the explosive into gas by detonation, with correspondingly rapid expansion and cooling of the products, was supposed to constitute another safety factor, but had proved a delusion. With the disappearance of these supposed elements of safety, the permitted explosives now stand side by side with gunpowder, possessing a common danger, and requiring common precautions equally effective for both.

The ignitions of gas and coal-dust by detonating permitted explosives is no doubt due to the intense potency of their heat-energy instantaneously developed, and exalted temperature. This is illustrated by their effect in the cannon at Woolwich testing station. Gunpowder, even in charges of 7 to 9 ounces, has very little, if any, effect upon the bore of the cannon; but the small charges of 2 to 3 ounces of detonating explosives literally melted and washed out the steel-liner or bore at the breech-end; and as this happened in some thousandths of a second (the period of detonation) it is evident that the temperature developed by the detonating explosives greatly exceeded the temperature developed by gunpowder. The report

* *Trans. Inst. M. E.*, 1895, vol. ix., page 342.

upon the Woolwich testing station records that 300 shots of the original test-charge, practically washed away the breech-end of the steel-liner of the cannon.* This effect became more pronounced when the Special Test was adopted; and the increased charges, from the equivalents of 2, to 3 and 4 ounces of dynamite, reduced the life of the steel-liner by 80 per cent; that is to say to 20 per cent. of the life when the smaller charge was used.† The induced strains of the larger charges necessitated additional strength to the cannon; but it is reported that with the new cannon the life of a liner is rarely more than 80 shots and has been as low as 48, or a maximum of 4 and minimum of little more than 2 tests of explosives.‡

When the fact is considered that 48 to 80 charges of 3 to 4 ounces of permitted detonating explosives melt and wash out the steel-bore of a 26 cwts. cannon, and that 6 to 12 ounces of these explosives are ordinarily used in coal-mine shots, some conception may be formed of the exalted temperature with instantaneous smelting potency developed by these explosives in coal-faces and canches; and how they ignite fire-damp, coal-dust, and even coal-face and workings, as at the Pemberton, Maypole and Orrell collieries.

In the discussions upon explosions due to coal-dust, it has been urged that the impalpable dust is the agent in both origin and propagation; and this must be so, as fineness of division facilitates the process in which the dust yields up its volatile gases to produce explosion. To prevent the production of such dust, and remove it if formed, is probably one of the most difficult and urgent problems in mining to-day, in view of the potential peril of the dust in originating and propagating explosions. Fine dust is necessarily produced in holing the coal-face, especially by coal-cutting machines, and by blasting. There is also deposition of dust by leakage through the joints and doors of the wagons, and sweeping effects of air-currents, during transit. Where explosives are employed in getting the coal, the

* *Twenty-second Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1897*, page 140.

† *Twenty-fourth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1899*, page 119.

‡ *Twenty-fifth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1900*, page 128.

quantity of dust in the working-face depends partly, and in the haulage-roads greatly, upon the explosive used. It is a fact of constant observation that the detonating explosives, with a recent exception (cheddite), chamber the hole, and by their enormous crushing force (on one occasion a pressure of 111 tons per square inch was registered at Woolwich testing station)* reduce the coal round the charge to an impalpable powder; and by their violent impact shatter and shake the remainder, so that disintegration occurs in the rocking of the wagons on the haulage-roads, producing more dust *en route*. The result is diminished coal over the screens compared with the quantity when gunpowder was used; but the more serious question, as regards safety, is the fact that part of the loss is left in the mine as fine dust, along the roads from the coal-faces to the shaft, and remains a peril there until made wet.

In practical blasting, it is not possible to neglect these important questions of temperature and pressure developed by explosives, as elements of danger both in the ignition of gas and coal-dust, and the production of the fuel that sustains propagation; but the Woolwich testing station has not the equipment for such determinations. The Woolwich apparatus determines whether or not certain standard explosives, in defined physical conditions and covers, and small charges, can be fired through, say, 27 feet of highly inflammable gas without igniting them. The questions of temperature and pressure are not raised in the test, nor the velocities due to the pressures. The fact established by Sir H. Davy that time of contact was a factor in the ignition of gaseous mixtures, is ignored by the Permitted List. There are now 45 permitted explosives, 43 of which are detonating explosives, that is to say explosives that instantly develop enormous pressures, shooting their products of exalted temperature through the 27 feet of inflammable gas, at velocities that disallow time-contact for ignition. It cannot therefore excite surprise that these permitted detonating explosives that melt and wash away the bore of the cannon, when fired in mines (where the hot products are necessarily localized and imprisoned) ignite both gas and coal-dust and initiate ex-

* *Twenty-second Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1897*, page 139.

plosions; inasmuch as the absence of time-contact is the principal condition in passing the Woolwich test. This principle, which was advanced by the "Flameless Explosives Committee" of The North of England Institute of Mining and Mechanical Engineers,* and the author,† before the Woolwich test was instituted, goes a very long way to explain why the purpose of the Woolwich test to give mine-owners a list of explosives that could not, like gunpowder, cause explosions of gas and coal-dust, has failed of fulfilment; and why the permitted explosives and gunpowder cause explosions of both that are indistinguishable.

It would be difficult to overestimate the value of the practical judgment of the industry in this subject, and an illustration appeared a few years ago in the reports of two mines-inspection districts. Probably it is not too much to say that the Explosives Order has been administered in every mines-inspection district with the intention of effecting the exclusive use of permitted explosives; and the universal prohibition of gunpowder was the policy in official circles, and pressed upon the management of mines. In these circumstances, the exclusion of gunpowder from coal-mines in 1898, would have been regarded as a natural result in public opinion. The merits as well as the demerits of the case were, however, well known in the industry, and in the year 1900, the annual report for the North Staffordshire mines-inspection district records that, of the 1,313,068 shots fired, 564,754 or 43 per cent. were charged with ordinary gunpowder;‡ and the report for the Midland mines-inspection district records that, of the 2,034,723 shots fired, 976,487 or 48 per cent. were also charged with this old explosive.§ In the management of coal-mines

* *The North of England Institute of Mining and Mechanical Engineers: Report of the Proceedings of the Flameless Explosives Committee*, 1894, page 39.

† *The Origin and Rationale of Colliery Explosions*, by Mr. Donald M. D. Stuart, Bristol, 1895, pages 123-128.

‡ *Reports of H.M. Inspector of Mines for the North Staffordshire District (No. 10), to H.M. Secretary of State for the Home Department, under the Coal-mines Regulations Acts, 1887 to 1896, the Metalliferous Mines Regulation Acts, 1872 and 1875, and the Quarries Act, 1894; for the Year 1900*, by Mr. W. N. Atkinson, London, 1901, page 40.

§ *Reports of H.M. Inspector of Mines for the Midland District (No. 8), to H.M. Secretary of State for the Home Department, under the Coal-mines Regulation Acts, 1887 to 1896, the Metalliferous Mines Regulations Acts, 1872 and 1875, and the Quarries Act, 1894; for the Year 1900*, by Mr. Arthur H. Stokes, London, 1901, page 32.

there is admittedly both desire and readiness to adopt official views calculated to promote safety of life and limb; and the continued use of gunpowder of which the above are examples in two districts only, represents the conviction of practical judgment as to its safety, which has been now confirmed by experience with the permitted explosives in the six years 1898-1903. When the Explosives Order had been in force only three years, however, it was observed that safety was not assured by the composition of the permitted explosives, and the following practical opinion was reported:—"It is to the decreased number of shots fired and the placing of the shot-firing in the hands of an official of the mine, that I attribute the increased safety, rather than to the composition of the explosive used."* The corollary of this opinion is Table II., recording the explosions due to shot-firing, and showing that 71 explosions had occurred during the régime of the Explosives Order, but only 45 in the similar antecedent period.

The Explosives Order has, however, led to large development in explosives, and it is fairly claimed that probably some of these would not have been discovered, but for the Woolwich test shutting out the precursor. One of the most valuable developments was the bull-dog bobbin, which supplied a highest-grade gunpowder, to Government standard in composition, quality of ingredients and strength. Compared with common blasting powder, it contained 37·27 per cent. more saltpetre, with 93·96 per cent. less sulphur, and 39·19 per cent. less charcoal, and occupied more than twice the time in manufacture; in a word, it was a mixture of pure saltpetre and charcoal with the addition of only 1 per cent. of sulphur, incorporated to a perfection never before reached in mining powder. The author subjected bull-dog to protracted trials, some of which were published,† which led him to the conclusion that it was the most effective blasting agent that had been produced for coal-mines, and this conclusion was shortly afterwards adopted at the numerous mines where it was used. It was published in the Permitted List of

* *Reports of H.M. Inspector of Mines for the Midland District (No. 8), to H.M. Secretary of State for the Home Department, under the Coal-mines Regulation Acts, 1887 to 1896, the Metalliferous Mines Regulations Acts 1872 and 1875, and the Quarries Act, 1894; for the year 1900*, by Mr. Arthur H. Stokes, London, 1901, page 26.

† "A New 'Permitted' Gunpowder," by Mr. Donald M. D. Stuart, *The Colliery Guardian*, London, 1900, vol. lxxix., page 126.

July, 1899, and was gradually introduced towards the end of that year; but, commencing the year 1900 in competition with 30 explosives on the Permitted List, most of which had already occupied the field for many months, bull-dog rapidly gained adoption, and in one mines-inspection district was used in 348,023 shots, or one-third of the shots charged with permitted explosives in that year:* in round figures, from 1½ to 4 times more than any other permitted explosive. It would be difficult to find more practical evidence of its safety and utility in the judgment of the mining industry. In October, 1899, the Secretary of State altered the Woolwich test, and as bull-dog could not pass the Special Test, it was excluded from the Permitted List.

It has already been shown that explosives that passed the Special Test, namely, amvis, roburite and saxonite, caused colliery explosions and afforded practical proof that the new test did not produce a safer explosive. It has been remarked on many occasions that the gaseous mixture of the Special Test, namely, 15 per cent. of coal-gas and 85 per cent. of air, has not, and cannot have any existence in a coal-mine; and if it had, no human being could live in it to even charge a shot. A test in such a gaseous mixture, cannot determine the safety-value of an explosive for use where that mixture has no existence. It is claimed for the test that an explosive which will not ignite such a gaseous mixture, is much more certain not to ignite the less inflammable and fractional quantity of gas in which it is possible to fire a shot in a mine, and in fact such an ignition is inconceivable. The ignitions at Pemberton, Maypole and Orrell collieries have proved the contrary, and deprived the test of any practical value for determining whether an explosive will or will not ignite gas or coal-dust in a mine. It has, however, led to a solution of the difficulty sometimes experienced with bull-dog both in crumbling at the ends of the bobbin and the paper enclosing it. These difficulties are removed in bobbinite by coating the bobbin with wax, and it was submitted for trial at Woolwich testing station, to ascertain whether the

* *Reports of H.M. Inspector of Mines for the Midland District* (*No. 8*), *to H.M. Secretary of State for the Home Department, under the Coal-mines Regulation Acts, 1887 to 1896, the Metalliferous Mines Regulation Acts, 1872 and 1875, and the Quarries Act, 1894; for the Year 1900*, by Mr. Arthur H. Stokes, London, 1901, page 32.

waxen covering increased its sensitiveness to ignition by external spark. Two bobbins, one waxed, the other in the paper wrapper, were exposed to a shower of "golden rain" fireworks, and the experiment repeated. In every case, the bobbin in the paper was ignited and communicated ignition to the waxed bobbin. The waxed bobbin was then placed alone and subjected to the "golden rain," but it was not ignited, although the wax coating was pitted with small holes where the sparks had partly melted it.* This development prevents the crumbling and dust with bobbins, protects them from breakage, dispenses with paper or loose covering, and provides tangible safety against the accidental ignition of the bobbin by sparks and open lights. It is, therefore, a practical advance towards the prevention of those regrettable and preventible accidents that have arisen in the careless handling of the bobbin-form of gunpowder.

Having now traced the development of the new explosives for coal-mines, and their behaviour in practical mining, as compared with the promises of safety which commanded so much attention, and the tests upon which their adoption had been compulsorily enforced; having also endeavoured to elucidate the conditions in experiment and practice so as to ascertain the cause of their opposing results, and the failure of the Woolwich tests to provide explosives capable of giving a higher standard of safety than gunpowder, or even so high; the author ventures to suggest that coal-mining can derive no useful service by enlarging the present Permitted List of 45 explosives by means of the Special Test; and that the subject demands the consideration of the Institute for the purpose of devising another method of selecting explosives for unsafe mines, and every coal-mine, so that the simplest (because all round safest) and most efficient explosives may be available, with the valuable precautions taught by the practice of the last six years; and thereby the increasing perils of explosions and accidents since the Permitted List came into force, may be arrested and reduced.

The PRESIDENT (Mr. T. W. Benson) moved a vote of thanks to Mr. Stuart for his very interesting paper.

Mr. A. L. STEAVENSON seconded the resolution, which was cordially approved.

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* *Twenty-eighth Annual Report of H.M. Inspectors of Explosives; being their Annual Report for the Year 1903*, page 139.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
FEBRUARY 14TH, 1905.

MR. JOHN GERRARD, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. YOSHIMA SAIKE, Mining Engineer, Jagawa Colliery, Buzen, Japan.
Mr. KÛCHIRO TAKAGI, Mining Engineer, The Miike Collieries, Chikugo, Japan.
MR. HERBERT TATLOCK WILKINSON, Electrical and Mechanical Engineer, 78, King Street, Manchester.

Mr. JAMES ASHWORTH'S "Notes on the Crow's Nest Coalfield, British Columbia," were read as follows:—

NOTES ON THE CROW'S NEST COAL-FIELD, BRITISH COLUMBIA.

By JAMES ASHWORTH.

Crow's Nest Coal-field.—The Crow's Nest coal-field is situated immediately west of the summit of the Rocky Mountains, about 370 miles from the Pacific coast, and practically the whole of it lies in British Columbia. The coal-field is of Cretaceous age, and the rocks of this section cover an area of about 500 square miles; but the coal-field has an area of only about 230 miles and is of leg-of-mutton shape, with a length from north to south of about 35 miles, and a width from east to west varying from 4 to about 11 miles. It is bounded on the west by the Elk river, which runs parallel to the upturned edges of the measures, and the outcrops of the coal are found commencing at an elevation of from 1,500 to 2,000 feet above the river, with a dip to the eastward of from 20 to 40 degrees. The coal-field is in the shape of a flat-bottomed basin, and the coal therefore crops out with its upturned edges to the north, south, east and west.

The coal-field is based on the Devono-Carboniferous limestone, and in ascending order, from this base, there are beds of dark shale and soft calcareous shales, known as the "Fernie shales," which have been much crushed and folded. The coal-seams above have not, however, been affected to the same extent, particularly on the west and south sides, and it has been assumed that the very hard beds of conglomerate (consisting of black and grey chert, embedded in a silicified matrix) and gritty sandstone (shown at the top of the section of the Morrissey coal-field, made by Mr. James McEvoy),* have resisted the eroding, crushing and folding forces that are in evidence elsewhere.

* "Summary Report on the Operations of the Geological Survey for the Year 1900," by Dr. G. M. Dawson, *Annual Report of the Geological Survey of Canada, 1900*, 1903, vol. xiii., section A, page 87; and *Ibid., 1901*, 1904, vol. xiv., section A, Nos. 759 and 767, maps.

The total thickness of the Cretaceous rocks in this coal-field has been estimated at from 12,000 to 13,000 feet, and in the section before referred to, there is a thickness of about 198 feet of workable coal in a depth of 1,847 feet of strata. Seams of 3 feet and under are omitted from the calculation.

Only a very few years ago, the Crow's Nest coal-field was a *terra incognita*, and the first reference made to it was in the report of the Geological Survey of Canada, 1880-1882. Subsequently to this and for some eight years it was persistently prospected by Mr. William Fernie (after whom the town of Fernie is named), and during this period (1889-1897), a syndicate was formed to develop, what Dr. Dawson called "one of the most remarkable coal-basins known." In the latter year, an arrangement was made with the Canadian Pacific Railway Company for the construction of the Crow's Nest Railway from Dunmore to Kootenay Lake, a distance of 394 miles. The Crow's Nest Pass Coal Company, Limited, was incorporated by Dominion charter in 1897, and now owns 250,000 acres of land. This company has opened mines at Michel at the northern end, at Carbonado (Morrissey) at the southern end, and at Coal Creek (Fernie) in the centre of the western side. The Canadian Pacific Railway Company and other companies own coal-lands in this area, but nothing more than exploratory work has been done up to the present time. The railway-track reached Fernie in 1898, and the output of coal has been increasing year by year, until it is now equal to about 5,000 tons per day; and the coke-production amounts to about 1,500 tons per day.

Samples of the seams of coal collected by the inspectors of mines gave the following percentage-analysis:—Moisture, 0·91; volatile combustible matter, 19·01; fixed carbon, 69·93; ash, 9·83; and sulphur, 0·32. The coke made from these coals is long, lustrous and strong, and is shipped to the smelters in Canada and the United States, *via* the Canadian Pacific and Great Northern railways.

At Coal Creek and Carbonado, the valleys are so narrow, where the mines are opened out, that the coke-ovens (bee-hive) are placed at some distance from the mines; but at Michel, they are close to the works.

A peculiar legislative restriction is placed on the Crow's Nest Pass Coal Company, by which they are prevented from charging

more than 8s. 4d. (2 dollars) per ton for run-of-mine coal at the mines.

Most of the coal-seams are soft, and produce a large proportion of small slack.

The seams of coal, now being developed in several places, have not been absolutely correlated, but Mr. J. McEvoy places Nos. 61, 63 and 71 in his Morrissey section, as being the same as the three seams of coal at Coal Creek, which are respectively 10 feet, 30 feet and 6 feet thick. No. 61 seam will therefore correspond with the Fernie mine (Coal Creek, No. 2), in which the explosion occurred in 1902; and with No. 1 mine, Carbonado, where the huge outbursts of gas occurred.* Although the thicknesses of the coal-seams are much the same at both places, the intervening strata have thinned to the north, thus, 140 feet and 197 feet, or a total of 337 feet, become 60 feet and 42 feet, or a total of 102 feet, showing a reduction of 235 feet. It would seem that this thinning process is continuous in a northerly direction, and in the Frank-Blairmore coal-field (adjoining the Crow's Nest coal-field on the north, and divided from it by the main range of the Rocky Mountains), the productive thickness of the Lower Cretaceous measures is placed by Mr. W. W. Leach at 740 feet, with 125 feet of coal, thus showing a great thinning of both coal and shale.

Frank-Blairmore Coal-field.—The Crow's Nest and Frank-Blairmore coal-fields are practically one coal-field separated by great upheavals, foldings and crushing of the strata.

From the "Loop," say, 3 miles east of Michel, the Devono-Carboniferous rocks forming the eastern boundary of the Crow's Nest coal-field, are in evidence nearly as far as the eastern end of the Crow's Nest Lake, where there is a faulted contact with the Upper Cretaceous and Laramie measures. These measures continue for the next 4 miles, and are followed by beds of volcanic ash, agglomerates and Flathead shale beds, for 1¼ miles, until the Lower Cretaceous coal-measures are again met with near Coleman. From Coleman to Frank, the coal-field is very much disturbed, and at Frank the limestone is pushed right through the coal. At the western contact of these strata, there is a wellknown sulphur-spring, and at its eastern contact the

* *Trans. Inst. M. E.*, 1905, vol. xxix., page 56.

coal-measures are turned up, and, in fact, partly turned over by the limestone-upheaval. This vast intrusion of limestone on the north side of the railway is known as Bluff Mountain; on the south side as Turtle Mountain; and the space between, through which the railway passes, is known as the Gap. For about 4½ miles east of Frank, the coal-measures are disturbed and folded, and a fault forms the contact with the coal-seams and lignites of the Upper Cretaceous and Laramie measures. The Upper Cretaceous coal-seams have been opened up to only a very limited extent.

One of the most noticeable of the great disturbances and movements of enormous masses of limestone-rock in this district is clearly demonstrated by the position of the Crow's Nest Mountain, perched on the Upper Cretaceous measures, about 4½ miles north of the railway. This mountain is unclimbable by most people, but during last summer Mr. Edward Whymper's party succeeded in planting a flag-staff and flag on the summit. Mr. Whymper described it as the driest mountain that he had ever climbed, as it was devoid of either water or snow.

Other notable disturbances are common in the Alberta district of Canada, and an instance, near Banff, may be interesting, as the coal-measures there are based on the limestone and also covered with limestone, and the coal-seams are both bituminous and anthracitic.

Rock-slide at Frank.—At Frank, where a huge rock-slide occurred about 4 a.m. on April 29th, 1903, the coal-measures, as previously noted, have been cut through and tilted by the limestone forming Bluff and Turtle Mountains. An adit-level has been driven into the coal near the foot of Turtle Mountain, by the Canadian American Coal Company, Limited, to a coal-seam, from 12 to 16 feet thick. Extraction of coal by this level commenced in 1901, and developments had been carried out so vigorously from that date up to the time of the accident that the output had reached 600 to 1,000 tons per day. The main level had been driven 5,600 feet, and some of the rooms had been worked up nearly to the outcrop. The precise height of the mountain above the valley does not seem to have been known, but it was probably about 2,500 feet. There were no premonitory symptoms of a fall, and work was proceeding as usual at the

mine. A train of loaded cars had just been drawn out of the colliery-siding, when, about 4 a.m., a fearful rumble was heard, and the eastern face of the mountain slid down into the valley with enormous velocity. The only living witnesses of the fall were the train-hands. All the men engaged at the colliery-tipple, the cars, staging, machinery, coke-ovens and dwelling-houses with their inmates, were swept away in a moment, and of the 83 people, known to have lost their lives, only 6 bodies were recovered. No one who has not been to the place and walked over the fallen mass of stone, and seen rails on end and other materials just showing above the débris, can form any adequate idea of the occurrence, and no photographs can do more than give a vague idea of the vast mass or sea of broken stones, which covers 900 acres of ground. A length of two miles of the Canadian Pacific railway-track was completely buried, and a mile or more of the Grassy Mountain railway. The brakeman and operator of the train, which had just pulled out of the colliery-siding, were the first men to cross the fall, and they did so to stop a passenger train and thus avert further disaster. The débris, as it lies in the valley to-day, gives a spectator the idea of a huge wave breaking on the sea-shore, with two gigantic petrified billows occupying about the centre of the valley, and the broken water (of stones) running up Bluff Mountain on the opposite side of the valley, to a vertical height of 250 feet above the original valley.

At the time of the disaster, 19 men were engaged in the mine, 17 of whom saved themselves by digging a way out; but the other 2 are supposed to have been out on the tipple, and to have been swept away with the staging and machinery. The men who escaped, on getting out, said that their first intimation of something having gone wrong was a "surging of the hanging-wall, and a crushing or falling of coal all around them," giving them the idea that an explosion had occurred.

So far as the writer knows, it is still an open query as to what set 500,000,000 cubic yards of limestone-rock in motion. Several theories have been propounded, one of which was that there had been an earthquake, but there does not appear to be anything to support this suggestion, any more than that at Lille, 4 miles to the north, and at Blairmore, 2 miles to the west, people were awakened out of their sleep by the noise and shock

of the falling mass. Another theory was that water, formed from melting snow, had found its way to the base of the mountain and had thus formed a slippery bed, over which loosened rock, pressed down by the superincumbent mass above, commenced to move, and thus brought about the fall. It was also suggested that a hard night's frost, following a warm opening day of spring, was the force which set the mass in motion. Many other theories have been suggested, but they are quite outside the possibilities of the occurrence. The writer thinks, as the Cretaceous rocks had been weakened and broken by upheaval and exposure on both sides of the outcrop of the coal-seam, that the removal of the coal had the same effect as taking out a sprag from underneath the foot of Turtle Mountain, and that the movement was thus originated. It may be observed, however, that the damage done within the mine was very slight, excepting near the entrance.

The adit-level has now been reopened, and a pit has been sunk near the Gap; and supposing that the working of the coal-seam from the adit-level was the disturbing cause of the disaster, it appears possible, if not probable, that at some future date the disaster may be repeated, and the whole of the remaining portion of the town of Frank might be swept away. The number of empty houses in the town is sufficient evidence to a stranger that the miners of the district have not recovered sufficient confidence in the stability of the face of Turtle Mountain, to take up their residence beneath its shadow.

In conclusion, the writer acknowledges the courtesy and valuable information and assistance he had received from Dr. Robert Bell, director of the Geological Survey of Canada; Mr. James McEvoy, geologist to the Crow's Nest Pass Coal Company, Limited, and late of the Geological Survey of Canada; Mr. Frank B. Smith, inspector of mines for the North West Territories; and Mr. O. E. S. Whiteside, of Blairmore.

A vote of thanks was passed to Mr. James Ashworth for his paper.

Prof. W. Boyd Dawkins said that he had seen some of the coal-seams in the region referred to, not far from the Rocky

Mountains. An enormous deposit of coal exists in the Cretaceous rocks, and when he was there about 15 years ago they were boring, and had discovered two thick seams of coal. A blower of gas, coming up one of the bore-holes, became ignited and destroyed the shaft. Thereafter the gas was used, instead of coal, for driving the boring machinery. The Crow's Nest coal-field is of vast importance, and it is extremely interesting from the fact that in some places where the pressure and the crushing have been very great, the coal, described as a coking coal, is converted absolutely into an anthracite. The local heat, resulting probably from enormous local pressure, had driven off the volatile material and left the carbon in the condition of anthracite.

Mr. Joseph Dickinson asked whether the mine at Frank was stowed with rubbish, so as to support Turtle Mountain. The land-slide seemed to have been a serious matter, something like the movement of the bog in Connaught of late. There were two ways of working mines: one was by temporarily supporting the face of the workings, and allowing the ground behind to fall; and the other way was to build up pack-walls to support the roof, and allowing the ground to subside gradually. The absence of pack-walls at Frank might have helped the mountain to slide down; and, seeing that the people had not got over their terror, it might be desirable to put them on their guard against the danger that arose through not building supports.

The President (Mr. John Gerrard) said that two years ago, an interesting report by Messrs. R. G. MacConnell and R. W. Brock was issued by the Canadian Government on the subject of the huge slide at Frank.* The main fact that he gathered from this report was that the mine was little disturbed, except near the entrance. It was a most extraordinary disaster, involving great loss of life and huge devastation.

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* *Report on the Great Land-slide at Frank, Alta, 1903.*

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
MARCH 14TH, 1905.

MR. JOHN GERRARD, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. J. U. ROGER GRAVE, Civil Engineer, 32, Northfield Terrace, Eastmoor Road, Wakefield.

Mr. FRANK PERCY, Mechanical Engineer, 3, Springfield Street, Wigan.

Mr. JAMES ASHWORTH'S description of "The Hunter V. Mine, British Columbia," was read as follows:—

THE HUNTER V. MINE, BRITISH COLUMBIA.

By JAMES ASHWORTH.

Aerial Cableway.—The Hunter V. and Double Standard claims, belonging to the British Columbia Standard Mining Company, Limited, are located on the top of a mountain near Ymir, and may be reached either by aerial cableway, horseback or on foot. The writer, with three others, took the cableway, starting from the Canadian Pacific Railway.

This aerial cableway, being one of the most recently erected in British Columbia, may be safely assumed to exemplify some of the best points in this mode of transportation. The distance between the terminal stations of the main cableway is 13,000 feet, and there are in addition two supplementary cableways, 1,800 and 500 feet long respectively. All three are worked separately, entirely by gravity, and the speed is regulated by powerful brakes on the clip-wheels at the upper stations.

On the main cableway, the top or fixed ropes, 1¼ inches in diameter, are in two lengths, the first being anchored at the top station (Fig. 1), and tightened from time to time as required at a station about midway (Fig. 2). At this station, the bottom length is also anchored, and is tightened, as required, at the bottom terminal station (Fig. 3).

On the Hunter V. cableway, the longest length between the supporting towers is about 1,800 feet, and the height above the ground is about 300 feet.

The haulage-rope, ¾ inch in diameter, is an endless rope. The buckets, of which there are 30, are placed at equidistances apart. When the rope is running at the rate of 400 feet per minute, 100 tons of ore can be easily transported and delivered into cars on the railway, in 10 hours; and this quantity can be increased by adding extra buckets.

Special cradles are used for carrying men and timber: two of these cradles being placed a short distance apart, so that the

timber, in transit, is supported at both ends, and, therefore, rides practically horizontally.

Every movement in the loading and unloading of the buckets, is, as far as possible automatic: thus, starting from the bottom station (Fig. 3), the catches which fasten the bucket in position when loaded, are opened by a fixed disengaging arrangement (Fig. 4), and the bucket (say, No. 26) dumps its contents into the ore-bin without a stop, and then, passing onwards round the return-wheel, continues its course back to the

FIG. 1.—TOP STATION OF THE MAIN CABLEWAY: THE ORE-BIN BEING FILLED BY THE SUPPLEMENTARY CABLEWAY.

mine with the bucket in an inverted position. The object of running the inverted bucket is to prevent water or snow from filling it whilst in transit. On arrival at the top station the bucket strikes an inclined-plane arrangement (Fig. 5), which forces the bucket into its proper position and allows the catches to close on to the hooks, and it is then ready for loading on the other side of the clip-wheel. Here a man, by means of three levers (Fig. 6), regulates the loading and the movements of the main cableway. In the intervals of time, between the buckets passing

this point, the man opens the shoot, A, close at his left hand, and fills the automatic loader, B, shewn below. On the arrival of a bucket (say, No. 23), a catch on the hanging frame of the bucket engages with a bar on the loader, B, and takes it in tow, and then the loader automatically discharges its contents into the bucket, while still in motion. The loader, after traversing a certain distance (Fig. 7), disengages from the bucket, and is brought back to its original position, by a counterbalance-weight, ready for loading from the bin. The ore-bin is filled

FIG. 2.—MIDWAY ANCHORAGE OF THE MAIN CABLEWAY.

by the supplementary cableway, and the buckets are dumped automatically (Fig. 1).

The buckets at the top and bottom stations (Figs. 4 and 5) are run from the cable on to fixed edge-rails, which conduct them round the clip-wheel and the return-wheel. Fig. 8 shows a line of derricks where the line makes a curve over one of the hills, and also shows an inverted bucket returning to the mine. The return-wheel (Fig. 4) is mounted on a movable platform, by means of which, and a heavy counterbalance-weight, the haulage-rope is kept in tension. The flanged wheels (Fig. 5) are

made in halves, so that the tread of the wheel, which is a separate part, and is fixed in position by molten lead, may be removed and replaced, without the expense of having an entirely new wheel.

FIG. 3.—BOTTOM STATION OF THE MAIN CABLEWAY.

This mode of transportation can be applied for the cheap transit of ore and materials over long distances, and for heavy outputs. Another aerial tramway, under erection, has a length of 3½ miles, and a capacity of 800 tons per 10 hours; and another

one, 4½ miles long, demonstrates that long and continuous lengths can be worked by this system, without its being necessary to place the ropes in one straight line. This mode of transportation being simple in its details, the movements being as far

Fig. 4.—Interior of the Bottom Station.

as possible automatic, and the working power being gravity, it is obvious that the cost per ton of material moved is very low.

When the writer travelled on this cableway, the time occupied in the transit to the mine, which is at an elevation of 5,500 feet above sea-level, was about 50 minutes.

Hunter V. Mine.—The Hunter V. group of claims includes, within its boundaries, portions of a limestone-deposit, the extent of which has not yet been fully ascertained. Locally, it forms the upper portion of the mountains near the head of Porcupine

Fig. 5.—Interior of the Top Station.

Creek, in the Ymir district. In the company's claims, the deposit is in the shape of a tongue, about 2,000 feet wide, and several miles in length. It is surrounded on three sides by a more or less altered gabbro of later origin, and belonging, it is

thought, to the Carboniferous age. The gabbro cuts into the limestone in places, whilst in others the limestone appears to be entirely surrounded by igneous rocks, just as if portions had become detached from the main mass, and had floated off into

FIG. 6.—LOADING SIDE OF THE TOP STATION.

the molten magma. No fossil remains have been discovered so as to establish definitely the age of the limestone.

Where least disturbed, the bedding planes strike in an east-and-west direction, and dip slightly to the south. In the process

of mountain-building, the mass has, like many other parts of British Columbia, been subjected to great strains, with the result that in places it is faulted, folded and contorted into confusing shapes, and the original structure is almost entirely obscured.

FIG. 7.—LOADING SIDE OF THE TOP STATION.

Fractures have also been formed, in which the circulating waters have re-deposited the lime as pure calcite, and these occur in irregular bands throughout the mass, varying in thickness up to 6 or 8 feet. At some other period, siliceous solutions appear to

have circulated throughout the formation, and silica has been deposited in the free state, as also in combination with lime, magnesia, etc.

The most conspicuous minerals that have been found are tetrahedrite (grey copper), zinc-blende, galena, pyrites and native silver.

The origin of the mineralization has not yet been determined, but it will no doubt be traced to the more recent eruptive rock surrounding it, and near the contact of which the largest mineralized areas have been discovered. It appears, however,

FIG. 8.—CURVED LINE OF DERRICKS.

as an impregnation in the limestone-deposit, and no lines can at present be laid down to trace it to its source, because irregularity of occurrence, and indefiniteness of shape, appear to be its chief characteristics.

The mineralization is more evident on the surface, in the bedding planes of the limestone, which the decomposition of the grey copper often colours green, whilst crystals of azurite are frequently seen scattered along these lines of enrichment.

Native silver, in leaves or plates, is more particularly met with on the faces of joint-planes, and may have been reduced and deposited there through the agency of surface-waters containing organic matter. Planes of fracture are common, some showing incipient movement and others none, but they appear to have an important bearing on the deposition of the ore, for in many cases it is found to be richer on one side of such planes than upon the other.

The opening of the mine has been principally confined to two areas, one on the Hunter V. claim, at the top of the hill, where the face of the quarry at present shows a width of over 70 feet of ore; and the other on the Double Standard claim, 1,400 feet distant, and vertically over 400 feet lower down the hill, where the Glory Hole is more than 120 feet wide, showing mineralization from side to side. Other outcrops of mineral have also been discovered on various parts of the property, though not at present opened up.

This deposit of limestone is unique in the district, and until it is further explored, a more comprehensive study of the occurrence cannot be made.

When the quarries are more fully opened out, the ore will be delivered into railway-cars at a cost of 4s. 2d. (1 dollar) or less per ton.

The ore, up to the time of the writer's visit, averaged about 13 per cent. of silica and 44 per cent. of lime; at times, the silica had run as low as 9 per cent., and the lime had risen to 48 per cent.; but experience had shown that an increase of silica did not necessarily mean a proportionate fall in the percentage of lime. These figures show that this ore is a valuable flux to the smelters. The ordinary limerock, which is used by the various smelters as a flux, when delivered at Nelson or Trail, costs about 6s. 3d. (1½ dollars) per ton, and at Northport 2s. 8½d. (65 cents.) per ton; and such limerock contains about 48 per cent. of lime and 8 per cent. of silica.

In what form the gold and silver are combined has not yet been determined, excepting so far as the native silver, and the silver contained in the grey copper, are concerned. The gold-contents have proved to be relatively higher in the Double Standard than in the Hunter V. claim, and it is in the former that the most siliceous material has been found.

Conclusion.—These few notes would, the writer thinks, be incomplete, without a reference to the excellent food provided at the mining camps, fully equal to an average hotel; and the cook, particularly if he happens to be a white man, receives a much higher salary than a good clerk will receive in this country. A white cook, who satisfies the miners, is a valuable acquisition both to masters and men.

At some camps, which are in a sense out of touch with civilization, there is no actual observance of Sunday, because it has been found that its non-observance is a lesser evil than idleness.

The writer's thanks are particularly due to Mr. N. Carmichael, Mr. J. J. Campbell, Mr. J. Johnson and Mr. W. S. Riblet for the technical details recorded in this paper.

Mr. William Saint, in moving a vote of thanks to the author of the paper, said that the installation of aerial rope-haulage was on a very large scale, and there were few opportunities of studying the practical side of the question in Great Britain. There were two small installations in Lancashire: in each of those cases the endless rope travelled and carried the loads; but in that of the Hunter V. mine, probably owing to the steeper inclinations of the hills which were traversed, the carrying ropes were fixed, and these were supplemented with an endless haulage-rope to which the loads were attached.

Mr. H. Stanley Atherton, in seconding the motion, remarked that he had seen an aerial rope at work similar to that described in the paper, but on a smaller scale. The longest of those that he had seen was 7,000 feet.

The motion was unanimously adopted.

Mr. George H. Winstanley read the following paper on "A Fatality caused by Low-pressure Electric Current in a Lancashire Colliery":—

A FATALITY CAUSED BY LOW-PRESSURE ELECTRIC CURRENT IN A LANCASHIRE COLLIERY.

By GEORGE H. WINSTANLEY.

Introduction.—In the course of the discussion upon Messrs. Philip C. Pope and Norman D. Cameron's paper,* the writer was impressed by the illustration introduced by Mr. Pope, with reference to the relative dangers of high-tension and low-tension electric currents. The writer already held similar views on the subject, but the singularly apt illustration had not occurred to him. It will be remembered that Mr. Pope expressed the opinion that, although high-pressure current was generally supposed to be more dangerous, as a matter of fact the greater proportion of accidents, serious and fatal, were in connection with low pressure. Mr. Pope suggested, in explanation of this, that where the danger is of, say, a mild nature, where the risks of fatal results are supposed to be small, an amount of indifference and carelessness results, not to say negligence, leading workmen to do things, and incur risks, which they would never dream of doing where the danger is great and the result certain destruction. The illustration used by Mr. Pope was that afforded by a level-crossing on a railway: with a train some distance away one would not hesitate to cross the line, with something approaching carelessness in the act. But if the train, an express rushing along at 60 miles an hour, is only a few feet away, one would never attempt to cross the line until the train had passed: to make the attempt would, of course, be to meet a positively certain and violent death.

It would appear that an element of danger, once recognized, becomes its own safeguard against accident. It is not considered necessary to fence the edge of a railway-station platform, although it may be occupied by numbers of people, whilst trains are rushing through at high speeds. It is not even con-

* "Practical Comparisons of Continuous-current and Polyphase Electrical Systems as applied to British Collieries," *Trans. M. G. S.*, 1904, vol. xxviii., page 652.

sidered necessary to warn people that they must not stand in front of the trains, nor on the edge of the platform.

Unfortunately, in connection with electrical matters, people cannot always be got to recognize, as they should, that electricity, like other forms of energy, must be treated with a certain amount of care; and still more unfortunately, when anything does go wrong, it does not seem to occur to anyone to attach the blame to anything but to the electricity.

The writer thinks it is unfortunate that the new regulations seem to convey the impression that low-pressure current calls for less stringent measures than medium or high pressures. It ought to be clearly understood by all those who have in any way to use electricity in mines, that electricity is dangerous, whether it be generated and used at 100 or at 10,000 volts. A current at a pressure of 100 volts has been known to kill; and current at 10,000 volts can do no more. In the one case, there may be a doubt as to the result, but in the other there can be no doubt. With a low-pressure current, although scores of people can speak to receiving shocks at 100, 200, 300, 400, 500 volts, or even higher (the writer has had 10,000 volts) without serious results, still the doubt is there, and one ought to take the benefit of the doubt, and avoid the risk of a shock at any pressure.

It should be clearly understood that although the pressure determines the amount of current which may pass through the body of a person receiving a shock, it is not the pressure but the quantity of current that kills: not volts, but ampères. The writer is not sure what current will prove fatal, but he believes that it is only a very small fraction (3/1,000) of an ampère. Generally speaking, the resistance of the human body being high, a low pressure is not capable of passing even this small current and the shock is neither serious nor fatal. Everything, however, depends upon circumstances, and it is quite possible that the conditions under which a person receives a shock, may be such that a sufficient current may pass to produce fatal results, even with a low pressure.

The circumstances favourable to a fatal shock at a low pressure would seem to include the following:—A moist state of the skin, a large area of contact, and the length of time during which the person remains in contact. The physical condition of

the person no doubt has a considerable influence, although in the case, hereinafter described, the man was perfectly strong and healthy in every respect.

Some few years ago, one of the writer's students was killed by a shock from a circuit at 100 volts. In that case, the unfortunate young man had only shortly recovered from a serious illness.

The Accident.—A fatal accident occurred at the Bower colliery, in June, 1904.

The installation at Bower colliery is a small one: the full-load capacity being about 30 electric horsepower. The generator is a six-pole continuous-current belt-driven machine, giving at full load, 93·25 ampères and 240 volts, at 475 revolutions per minute. It had, however, never been worked at full load, the total capacity of the underground plant being about 8 horsepower, namely:—A 5 brake-horsepower motor, working a three-throw pump, with rams 5 inches in diameter, and a small motor of about 3 brake-horsepower, working a small pump, with rams 2 inches in diameter.

It was from the cables conveying current to the last-named motor, that the man received the shock, which resulted in his death. The motor required current equal to 1 horsepower only, and the conductor used was a single strand containing seven wires of No. 20 standard wire-gauge. The lead and return cables were both placed on the same side of the road, they were armoured with galvanized wire, with the armouring left bare; and both cables were secured to the road-timbers by means of porcelain insulators.

This, no doubt, was an error of judgment. In connection with electrical appliances, one ought to be guided by expert advice, and installations should certainly be carried out by skilled electricians. Ignorance of important electrical principles, as in this case, may lead to serious results. No doubt it was considered, in so small an installation as this, at a low pressure, that expert assistance was unnecessary. The writer is well acquainted with the manager at this colliery, and has a high opinion of his abilities as a colliery manager. He is fully alive to the dangers attending colliery working; he would not knowingly allow anything to jeopardize the safety of the men

under his charge; and the writer has rarely met with one more zealous in making provision for the safety of his mine. The very circumstances which have been described seem to indicate on the part of someone, a desire to take what appeared to be every precaution. The writer feels it to be only fair to make these remarks, because he is anxious to avoid the appearance of attaching blame to anyone; and because the manager himself has been only too willing to place at the writer's disposal all the details of the case.

The provision of armoured cables was considered a measure of safety, and the securing of those armoured cables to porcelain insulators was meant to be a further safeguard. Unfortunately, lack of expert knowledge obscured the fact that what was meant as a safeguard, was really a source of danger. Armoured cables, with the armouring properly earthed, would have been comparatively safe, but armoured cables on porcelain insulators actually became bare live wires. Joints had been made in these cables, they had not been made by experts, and the electrical continuity of the armouring had been broken. If cables are armoured, the electrical continuity must be maintained; and where joints have been made, the armouring must be coupled as well as the conductor. In the case at Bower colliery, the joints had not been perfectly made; and, somehow, the armouring wires had made contact with live wires, so that the two cables became, to all intents and purposes, bare wires carried on porcelain insulators.

Wilfred Smith, the victim of the fatal accident, was a man of 26 years of age, strong and healthy. He was employed in connection with the haulage, in the brow down which the cables were taken to the small motor. The mine is wet and warm, and the inclination steep. Smith was naked from the waist upward, and at the moment of the accident had previously run some distance up the steep brow, to assist in lifting certain tubs, which had run off the rails. He was, at the moment, perspiring freely, as the result of his exertions in the warm and moist atmosphere, and possibly his heart would be pulsating vigorously after hurrying up the brow. Stepping back to allow the tubs to be drawn up, he stumbled and fell with the broad of his bare back against the two cables. Here were all the conditions favourable for a fatal shock, particularly a moist skin and a large area

of contact. At the moment of the accident, the deceased made a single exclamation and became unconscious. He was pulled away, and according to those who were present appeared to live for several minutes, during which time they attempted to restore respiration.

The foreman of the coroner's jury, which enquired into the cause of death, was the late Mr. W. W. Millington, and it was a matter of considerable regret that the writer found himself called upon to do what Mr. Millington had undertaken, namely, to bring the facts of this accident before the members. The inquest was attended by Mr. Gilbert Scott Ram, a Home Office electrical expert, who, with our President, Mr. John Gerrard, investigated the circumstances very minutely.

Mr. Gerrard then expressed the view, which the writer had always held, never more strongly than now, that one must not differentiate where electricity is concerned, at least in the direction of lessened precautions, whether the pressure be high or low; and electrical appliances for use in mines must be of the best. Officials and others, whose duties involve the use or control of electrical appliances, must possess a knowledge of electrical principles; and that knowledge must not be acquired experimentally, by doing things on the wrong lines until a fatal accident convinces us that the system is wrong. Engineers must make it their business to acquire that knowledge by a careful study of those principles: they are well enough known, and there is little excuse for ignorance on the subject. Only too much, in the past, have engineers relied upon what some people choose to call "practical experience," by which they mean the discovery that a certain procedure was dangerous, after it had been responsible for loss of life.

Mr. Joseph Dickinson, in moving a vote of thanks to Mr. Winstanley for his instructive paper, said that the Home Office were now issuing Special Rules to collieries on the subject. When he read them he thought that they were very lengthy, but from what Mr. Winstanley had now laid before the members their length really appeared to be justified. They were divided into as many as 11 sections, in addition to the definitions. The

latter served a double purpose in defining the different pressures: 250 volts being low pressure; from 250 to 650 volts, medium pressure; from 650 to 3,000 volts, high pressure; and anything beyond 3,000 volts, extra high pressure.

Mr. T. H. WORDSWORTH, in seconding the motion, said that he had listened with very great interest to the paper affording information respecting the accident at Bower colliery. He believed it was a recognized law of Nature that "length of time compensated for lack of intensity of action," and engineers should not expect that law to be broken in the case of electricity. If a low pressure were applied for a long time the result would be the same as from the application of a high pressure for a short time; and the fatality, which Mr. Winstanley had described, should make every engineer cognizant of the fact that low pressure had its dangers as well as high pressure.

The resolution was unanimously adopted.

Mr. ALFRED J. TONGE said that it had been pointed out by several of the witnesses before the Departmental Committee, appointed to enquire into the use of electricity in coal and metalliferous mines, that the high pressures in use on the Continent had not proved so prolific in accidents as the low pressures in use in this country. These witnesses spoke largely from the same standpoint as that taken by Mr. Pope, in the paper which he and Mr. Cameron recently read to the members, namely, that workmen were more afraid when they knew the pressure was high, and they kept at a greater distance from it on that account. He (Mr. Tonge) thought that much might be said in that regard; but he could not altogether agree with Mr. Winstanley, when he said that all was quite plain and straightforward as regards minimizing the dangers. There were many electricians, who did not recommend the earthing of the armouring of cables, and so according to some of them, the manager, at Bower colliery, would be doing the right thing in what he did; personally, he held the opposite opinion, but it was difficult to act contrary to the advice of a skilled electrician. Where two cables were used, one would always be more liable to go wrong than if the concentric system had been used. He (Mr. Tonge) thought that justice was scarcely done to the concentric system. The Departmental Com-

mittee had simply permitted its use, without apparently going into the real question as to how far it might be governed. The only regulation in the Special Rules is, that where the concentric system is applied, sufficient precautions shall be taken to safeguard it. He thought that from the standpoint of the safety of the workmen, who are not employed directly with the electrical plant—the men working on the roads, or the colliers passing along with their tools—the concentric system was the safest and best. There might be practical difficulties with it at the coal-face, where the electricity is being used; but, on investigation, it would be found that very largely underground accidents occurred on the roadways to men who were not, for the time being, directly employed at the electrical plant, and, therefore, the system that seemed safest to the great bulk of the men, should be considered. He (Mr. Tonge) thought that it would have been better to have stated in the different clauses of the Special Rules of the Departmental Committee what precautions should be taken in regard to the definite pressures of 250 volts, 650 volts, etc.; rather than define the pressures as low, high, or extra high. There would then be less tendency for any workman to imagine that a low pressure was comparatively safe, and a high pressure very dangerous.

Mr. S. E. Bastow said that he was constantly in touch, in various ways, with electricity, and perhaps it would interest the members to know what effects various shocks had had upon him. He had, under some circumstances, been unable to sustain a shock of 2 volts; although, under favourable conditions, he could withstand a shock of 60 volts without serious inconvenience. On another occasion, with his fingers soaked in acids and lead salts, he found that he could not do so. In the case of the deceased man, Wilfred Smith, there was a broad surface of contact with the wire, and he had taken the full voltage through his body. Probably, he received some considerable fraction of an ampère through his body. It was estimated that 3/1,000 ampère was fatal. It should not be forgotten (as Mr. Winstanley had stated) that it was not voltage that causes death: it was the amount of current through the tissues of the heart that killed, and the amount just mentioned would cause serious lesions of the heart. In the case in question, the man's skin being moist, it would offer a low resistance, and he might receive

½ ampère through his heart. That was the cause of death and not the usual shock, for the man was able to speak and lived for some time after the shock, although his friends were not able to restore him. Instances had occurred of persons receiving a pressure of 2,000 volts, and becoming unconscious. He had had that experience, and came round naturally without artificial respiration. Take the analogy of a rifle-bullet: if the velocity be high and the bullet small, the missile may go through a man's heart without killing him; but if a bigger bullet be used at a slower speed, the result would be death. It was the same with electrical energy: low pressure with broad and long contact would cause death; but at the same time, he did not agree with all that had been said about the relative dangers of high and low pressures. He thought that Continental experience had not extended over a sufficiently long time to prove the extra safety of the high-pressure system. Naturally, the use of a high-pressure system tended to greater caution on the part of the men; but it was possible that high pressures might cause faults in the system, that could not be easily foreseen, and they might cause accidents. He (Mr. Bastow) disagreed with Mr. Tonge as to the use of concentric cables: a motor might be used at a long distance from the generating plant, and when the current was shut off from the motor, a serious shock might be received from the cable. The shock was due to the capacity of concentric cables, and unless it was kept extremely low, it would be a source of danger. In his own case, he had had to handle switches connected with long lengths of concentric cables: on one occasion he took hold of one, and received such a severe shock that he was propelled across the station.

The President (Mr. John Gerrard) said that when on the Continent recently, he saw a notice-board containing a representation of forked lightning drawn across it in red paint and the following words: "Nicht berühren! Hochspannung! Lebensgefährlich!" The interpretation is as follows: "Do not touch! High tension! dangerous to life!" If such notice-boards were used in connection with electrical appliances in this country, it would be infinitely more serviceable than writing in chalk the word "danger." In electrical works in Germany, copies of Dr. Sylvester's method of restoring the victims of shock were posted, in the same way as, in other places, illustrations of the methods

for the restoration of persons apparently drowned were posted up. He had been told that there were better methods than Dr. Sylvester's; and he asked whether someone would tell the members what was the best method of attempting to restore persons suffering from electric shock. Mr. Winstanley was most kind in his reference to the manager of Bower colliery, who had charge of the men working in that mine and who deeply felt this sad accident and loss of life. There was one point in the paper that he would venture to criticize, and that was with reference to imposing the whole of the responsibility for the selection of the plant upon the manager of the colliery. The manager would not claim to be an electrical engineer; he would, probably, consult an electrical engineer; and he ought not to have suggested such an application of electricity as that which caused this sad fatality. The members were all anxious to use this new and convenient power, if it could be used with safety.

Mr. Philip C. Pope said that, when a man was installing a small electrical plant, he did not often realize that there was as much danger attached to a small as to a large installation. It was only a question of the length of contact, and of the man's condition at the moment to determine the result of contact. If a pressure of 1,000 volts for ½ second was too much, an equally bad effect would be produced by a shock of 500 volts extending over double the time: that was not the exact proportion, but it was approximately true. Much depended on the resistance of individual bodies: a very severe shock to one man might be a trifling one to another, and in his (Mr. Pope's) opinion, it mattered not how small the installation or how low the voltage, the same precautions should be taken in every case to ensure freedom from accident. He was very glad to see, from the Special Rules issued by the Home Office, that the earthing of wires and the due protection of machines would be enforced. Irrespective of the size of the plant, it should be properly installed in the first instance, and there would then be no difficulty afterwards.

Mr. G. H. Winstanley, replying to the discussion, said that it was gratifying to find that Mr. Bastow and Mr. Pope so completely endorsed his attempt to bring home the importance of seeing that electricity was only used under safe conditions.

DISCUSSION OF MR. J. ASHWORTH'S PAPER ON "OUTBURSTS OF GAS AND COAL AT THE MORRISSEY COLLIERIES, BRITISH COLUMBIA."*

Mr. J. Ashworth wrote that he had received the following information from Mr. Frank B. Smith, inspector of mines for the North West Territory, respecting outbursts of gas in his district. At Canmore, in the same coal-field as Banff, there had been several outbursts of gas, but of much smaller volume than those at Morrissey, and on April 9th, 1903, two men were suffocated by one of these outbursts. To guard against such outbursts as far as possible, the following precautions had been adopted, namely, (*a*) to keep a bore-hole ahead, and (*b*) to work the places as wide as possible.

At Medicine Hat, North West Territory, a town standing on Upper Cretaceous measures, bore-holes had been put down to tap the natural gas. One bore-hole, over 900 feet deep, supplied the town with light and fuel, and another (which had lately been put down by the Canadian Pacific Railway Company to a depth of 950 feet, to supply their repair-shops) found gas on January 25th, 1904, at a pressure of 25 pounds per square inch. The pressure and the volume of the gas did not, however, remain constant and continued to increase until, in ½ hour after being struck, it had reached a pressure of 445 pounds per square inch. A coal-seam was passed through at a depth of about 100 feet, but he did not know whether the gas came from the Upper or from the Lower Cretaceous measures.

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* *Trans. Inst. M. E.*, 1905, vol. xxix., page 56.

THE INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,
HELD IN THE ROOMS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE, LONDON,
JUNE 1ST, 1905.

MR. H. C. PEAKE, PAST-PRESIDENT, IN THE CHAIR.

THE LATE SIR LOWTHIAN BELL, BART.

The following correspondence was read:—

THE INSTITUTION OF MINING ENGINEERS,
NEWCASTLE-UPON-TYNE, *January 4th*, 1905.

DEAR SIR,

I am desired by the Council of The Institution of Mining Engineers to convey to you and your family a vote of deep sympathy and condolence on the irreparable loss which you have recently sustained by the death of your father, the late Sir Lowthian Bell, Baronet, D.C.L.

The Council further desire to place on record the great loss which the Institution has sustained by the death of their President.

In reviewing the great educational, commercial and scientific career of your late father, the Council feel that the loss which the community has suffered is one that cannot be easily regained. As a chemist, iron and steel manufacturer, colliery owner, coke manufacturer and railway director, the services which the late Sir Lowthian Bell rendered to the scientific world cannot be overrated; whilst the papers which he contributed on the various questions dealing with the phenomena of iron-production placed him in the front rank of the leading scientific authorities on the subject.

A pioneer in metallurgy and its allied sciences, Sir Lowthian Bell has left a name which will be remembered by all mining and metallurgical engineers.

I am, dear Sir,
Yours faithfully,
M. WALTON BROWN, *Secretary*.

Sir Hugh Bell, Bart.

MIDDLESBROUGH, *January 9th*, 1905.

DEAR SIR,

I beg to acknowledge receipt of your letter of the 4th, conveying to me and the members of my family the vote of sympathy and condolence passed by The Institution of Mining Engineers on the death of my father. I beg you will communicate to the Council our sincerest thanks for their vote. It is a

great satisfaction to us to be assured of the high regard and esteem in which my father was held, and the vote of your Council, consisting of gentlemen intimately connected with the great industries of the North, and therefore peculiarly able to form an opinion of the value of my father's services, is most highly appreciated by us all.

I remain, yours very truly,

HUGH BELL.

M. Walton Brown, Esq.,
Secretary,
The Institution of Mining Engineers.

The SECRETARY stated that the Council had placed on record their condolence in the following terms:—

The Council have received with the deepest regret intimation of the death of their esteemed President and colleague, Sir Lowthian Bell, Bart., one of the founders of the Institution, who presided at the initial meeting held in London on June 6th, 1888,* and they have conveyed to Sir Hugh Bell, Bart., and the family of Sir Lowthian Bell an expression of sincere sympathy with them in their bereavement.

It is impossible to estimate the value of the services that Sir Lowthian Bell rendered to The Institution of Mining Engineers in promoting its objects, and in devoting his time and energies to the advancement of the Institution.

The CHAIRMAN (Mr. H. C. Peake) said the members were met together to-day when they had reason to hope that they would have had an address from their President, who, had he lived, was to have given them one. No one could say what that address would have been, but it would doubtless have been one from which they would have learned much, and would have appealed to them all. The late Sir Lowthian Bell was not only a theoretical, but a most practical man—a rare combination, which placed him at the head of the coal, and of the iron and steel industries, and of many others. Many of his other friends must have felt his loss, but the members of this Institution felt it most strongly on account of the absence of his address that day.

It seemed but yesterday, though it was 17 years ago, that this Institution, with the initiation of which Sir Lowthian Bell had much to do, was founded. He (Mr. Peake) was present at the meeting when the formation of the Institution was suggested, at Newcastle-upon-Tyne in 1887.† Sir Lowthian Bell was then the President of the North of England Institute of Mining and

* *Trans. N. E. Inst.*, 1888, vol. xxxvii., page 155.

† "The Mining Institution of Great Britain," by Mr. Theo. Wood Bunning, *Trans. N. E. Inst.*, 1887, vol. xxxvi., page 167.

Mechanical Engineers—the pioneer institution of mining engineers—and in that capacity he gave a reception in the Theatre of the Royal Mining, Engineering and Industrial Exhibition, and it was very largely attended by mining engineers from all parts of Great Britain. Sir Lowthian was also, he believed, one of the founders of the Iron and Steel Institute.

He (Mr. Peake) had to express his great regret that Sir Lowthian was not there to take the chair that day.

The members then divided into two sections for the reading and discussion of papers. Mr. H. C. Peake (Past-President) presided over one section; and Mr. J. S. Dixon (Past-President) presided over the second section, in the rooms of the Royal Astronomical Society, Burlington House.

DISCUSSION OF MR. A. R. SAWYER'S PAPER ON "THE TRANSVAAL KROMDRAAI CONGLOMERATE."*

Mr. A. R. Sawyer (Johannesburg, Transvaal) wrote that the occurrence of quartz-schist and kaolin, near Rietfontein (Fig. 1, Plate XIX.†), confirmed his opinion that considerable reversed faulting occurred, in the Bezuidenhout valley, along a line of fracture cutting diagonally across the valley. The throw, which is considerable in the valley, accompanied by a lateral sliding movement, lessens towards the Salisbury and Jubilee mines, where the main dyke, 45 feet thick, has a throw of 250 feet.

Mr. T. Y. Greener's paper on "The Firing of Babcock and other Boilers by Waste-heat from Coke-ovens" was read as follows:—

* *Trans. Inst. M. E.*, 1904, vol. xxvii., page 457; and 1904, vol. xxviii., page 619.

† *Ibid.*, vol. xxvii., page 462.

THE FIRING OF BABCOCK AND OTHER BOILERS BY WASTE-HEAT FROM COKE-OVENS.

BY T. Y. GREENER.

The attention of colliery owners and managers has been largely directed during the past twenty years or so, among other matters, to the necessity for economizing in the quantity of coal consumed at colliery-boilers for the purpose of steam-raising. With that object in view, therefore, egg-end boilers have been almost entirely superseded by Lancashire and other descriptions of internally-fired boilers, high-class steam-engines have been, where practicable, introduced in place of the common engines at one time thought to be good enough for collieries, and generally advantage has been taken of every available expedient for reducing the quantity of coal burnt.

This policy has been so far successful, the writer understands, that it is quite practicable to-day, at a colliery equipped with the most modern appliances, to produce all the steam required without burning more coal than 1 per cent. of the output. Such a satisfactory result is of course unusual, and is very seldom realized at those pits which depend for steam entirely on hand-fired boilers.

At coking collieries, however, for many years past advantage has been taken of the waste-heat from coke-ovens for firing boilers; and it is well within the writer's knowledge that such collieries are in regular operation at which, over a series of years, the coal consumed for steam-raising varies from under 1 to 1½ per cent. of the total production.

It is evident, therefore, that the selection of suitable boilers is a matter of the greatest importance. While on the one hand it is very desirable to instal boilers of high efficiency as steam-generators; it is equally important on the other hand not to fix boilers on the oven-flues of such construction as will impede the draught of the ovens and so reduce the output of coke, and perhaps, at the same time, depreciate its quality and

mechanical condition. Obviously, therefore, the simplest boiler for the purpose was the egg-end, and it is many years since that class of boiler was first fired by waste-heat from coke-ovens. The writer has not had any experience with such boilers on coke-ovens, but figures shewing the results obtained have been published by Mr. A. L. Steavenson.

TABLE I.—PARTICULARS OF EVAPORATION-TESTS OF BOILERS ATTACHED TO COKE-OVENS AT THE UNDERMENTIONED COLLIERIES.

Name of colliery	Stanley	Bowden Close	Ushaw Moor	Esh	Stanley
Class of boiler	Babcock-and-Wilcox	Babcock-and-Wilcox	Babcock-and-Wilcox	Five-flued	Two Lancashire
Duration of tests	50 hours or 5 days	40 hours or 4 days	30 hours or 3 days	5 hours	10 hours
Average temperature of flue-gases at front of boiler degs. Fahr.	1,194	1,111	1,477	1,300	1,196
Average temperature of flue-gases at back of boiler degs. Fahr.	376	393	536	400	378
Average water-gauge at front of boiler ... ... inches	0·40	0·10	0·70	0·60	0·40
Average water-gauge at chimney inches	0·70	0·48	1·20	1·25	0·90
Average temperature of feed-water entering economizer degs. Fahr.	—	—	—	140	—
Average temperature of feed-water entering boiler .. degs. Fahr.	60	101	116	315	60
Average pressure of steam per square inch ... pounds	53	82	56	90	55
Coals coked per hour ... ,,	6,213	4,640	7,586	7,280	6,213
Water evaporated per hour ,,	9,432	4,325	11,197	11,270	4,500
Water evaporated per pound of coal coked ... pounds	1·510	0·930	1·476	1·540	0·720
Water evaporated per hour per pound of coal coked, assuming the temperature of the feed-water at 212° Fahr. pounds	1·780	1·069	1·653	1·410	0·849
Water evaporated per pound of coal coked, boiler and economizer combined, assuming the temperature of the feed-water entering the economizer at 212° Fahr. ... ... pounds	—	—	—	1·710	—
Water evaporated per square foot of heating surface of boiler pounds	3·330	3·030	3·960	—	2·500
Water evaporated per square foot of heating surface of boiler and economizer combined pounds	—	—	—	4·130	—

Naturally, in process of time as old plant wore out, more efficient boilers were introduced and fixed on coke-oven flues: hence, of recent years, it has been the common practice at coking collieries to make extensive use of the Lancashire boiler, the five-

flue modification of that boiler, and latterly of the Babcock-and-Wilcox boiler. The writer has boilers of each description working on coke-ovens at several of the collieries under his charge, and it may be of interest to members to compare the results obtained from each. For that purpose, careful measurements have been made of the quantity of water evaporated per hour from each description of boiler; and the writer has endeavoured in Table I. to present the results in such a manner that the comparative efficiency of each boiler may be determined. Table II. contains descriptions of the boilers, coke-ovens, main flues and chimneys of the several plants tested by the writer.

TABLE II.—DESCRIPTION OF BOILERS, OVENS, CHIMNEYS, ETC.

Stanley.—Babcock-and-Wilcox boiler, 126 tubes, each 4 inches in diameter and 18 feet long, and 2,823 square feet of heating-surface. Forty Hanson coke-ovens, 16 feet long, 4 feet 8 inches wide and 7 feet high, attached to a chimney, 106 feet high and 6 feet square. Sectional area of the main flue, 14⅜ square feet.

Bowden Close.—Babcock-and-Wilcox boiler, 63 tubes, each 4 inches in diameter and 18 feet long, and 1,426 square feet of heating-surface. Twenty common and 8 underflue beehive coke-ovens, 11 feet in diameter, attached to a chimney, 90 feet high and 4 feet 8 inches square. Sectional area of main flue, 16 square feet.

Ushaw Moor.—Babcock-and-Wilcox boiler, 126 tubes, each 4 inches in diameter and 18 feet long, and 2,823 square feet of heating-surface. Twelve Bauer coke-ovens, 39 feet 4⅝ inches long, 1 foot 7⅝ inches wide and 6 feet 10⅝ inches high, attached to a chimney, 150 feet high and 8 feet 10 inches in diameter. Sectional area of main flue, 24⅜ square feet.

Esh.—Five-flued boiler, 30 feet long and 9 feet in diameter, 1,426 square feet of heating-surface, and a Green economizer attached, with 1,300 square feet of heating-surface. Forty-two beehive underflue coke-ovens, 11 feet in diameter, attached to a chimney 150 feet high and 8 feet in diameter. Sectional area of main flue, 16 feet 6 inches.

Stanley.—Two Lancashire boilers, each 30 feet long and 7 feet in diameter, and 894 square feet of heating-surface in each. Forty Hanson coke-ovens, 16 feet long, 4 feet 8 inches wide and 7 feet high, attached to a chimney 130 feet high and 7 feet square. Sectional area of main flue, 15 square feet.

Having regard to the results of the experiments, it would appear that if the water evaporated per pound of coal coked be assumed to be the standard of efficiency, the best results are being obtained from the Babcock-and-Wilcox boilers at the Stanley and Ushaw Moor collieries, and that the five-flue boiler at Esh colliery takes the next place.

It is, however, most difficult to make a strictly fair comparison of the work of boilers in different coke-yards. The results in each case are influenced by the area and position of

the main gas-flue, the height and capacity of the chimney, and the number of hours that the majority of the ovens have been burning at the time that the ascertainment of the boiler-duty is being obtained. That duty varies at different times of the day, and is usually lowest between about 8 a.m. and 11 a.m., by reason of the fact that the majority of the coke-ovens it is intended to draw that day are by that time unloaded and are being charged, most likely with washed coal; hence, the temperature of the main gas-flue is cooled by the admission of cold air and to some extent by the water in the coal. As a result of that cooling, the efficiency of the boilers is (for the time being) reduced. It is not prudent, therefore, to rely absolutely on coke-oven boilers for an adequate supply of steam, and most coking collieries provide one or two hand-fired boilers to be used only at such times as those on the ovens are not steaming their best.

The writer has, at least, one colliery under his charge at which hand-firing is never necessary, and several others at which it is only resorted to on very rare occasions.

In preparing the figures already referred to, an endeavour was made to have the tests continued over a sufficiently long period in each case, so as to determine the duties of the several boilers during coal-drawing hours. The results in the night would undoubtedly be better than those in the day, and the boilers would be capable of producing more steam, because the ovens are all closed up and those loaded during the day are burning freely. Obviously, therefore, there would be a more ample supply of steam at coking collieries in the day, if the ovens were drawn at night instead of during coal-drawing hours. Difficulties would, however, arise with the workmen if such a system were generally adopted at beehive coke-ovens, and the probability is that coke loaded in the night-shift would not be so carefully selected as that loaded in the day-shift, and would, therefore, not be so readily saleable.

With regard to the comparative results of the Babcock-and-Wilcox and two Lancashire boilers at Stanley colliery, it is interesting to note that the two sets of boilers are placed one at each end of a battery of 80 rectangular coke-ovens, that the main gas-flue is divided in the middle and conveys the heat from 40 ovens to the Babcock-and-Wilcox and two Lancashire boilers respectively. Hence, both sets of boilers are working under pre-

cisely the same conditions as regards the number and class of ovens from which they are fired; but it is only fair to state that the Lancashire boilers are fixed somewhat lower than they ought to be, and there is thus an awkward bend in the main gas-flue, which undoubtedly impairs the efficiency of the boilers. The Babcock-and-Wilcox boiler was erected for the purpose of generating twice as much steam as the two Lancashire boilers, and it has more than accomplished the object in view.

At Ushaw Moor colliery, having regard to the temperature at which the gases are passing up the chimney, it is evident that the heating-surface of the boiler is not sufficient to utilize all the heat, that an economizer might with advantage be applied, and that its application would assuredly increase the efficiency of the boiler.

The efficiency of the Babcock-and-Wilcox boiler at Bowden Close colliery is not equal to that of similar boilers at Stanley and Ushaw Moor collieries, but the reason is to be found in the conditions under which the boiler is working: it is attached to a battery of beehive coke-ovens originally built, probably 60 years ago, without any idea of utilizing the waste-heat. The main gas-flue is largely exposed to the weather, and is too small for the purpose; whilst the water-gauge at the front of the boiler is only 0·10 inch; hence the draught on the ovens is very poor, and the volume of heat conveyed to the boiler is much less than it ought to be.

The boiler-plant at Esh colliery is doing excellent work, and, as a matter of fact, is evaporating more water than any plant with which it is being compared. This result is due to the Green economizer, working alongside the boiler, raising the temperature of the feed-water to 315° Fahr. Apart, however, from the economizer, the efficiency of the boiler is very satisfactory, and is only a trifle below that of the Babcock-and-Wilcox boilers at Stanley and Ushaw Moor collieries.

Considerable doubt was felt when the boilers were first attached to the coke-ovens at Esh colliery, as to whether such boilers would be successful, because the ovens from which they were to be supplied with heat were of the Dixon-and-Breckon underflue beehive type, and it was thought that possibly the waste-heat would not be sufficient to raise steam. The results, however, have been surprisingly good, and the somewhat large

expenditure incurred in installing the boilers will be fully repaid in five to six years by the saving of coal effected in the superseded hand-fired boilers.

There is an important aspect of the subject to which the writer would like to devote some consideration, and that is whether the results here described approximate, even remotely, to those which ought to follow from the amount of heat available for steam-raising. The quality of the coal used in the manufacture of coke is practically the same at each of the collieries to which the writer has referred, and that coal is regularly evaporating under ordinary circumstances in hand-fired Lancashire boilers 8 pounds of water at and from 212° Fahr. per pound of coal burnt. Obviously, all other conditions being equal, the best results in boilers fired by waste-heat from coke-ovens should be from those attached to ovens of the beehive type, in which part of the coal itself is consumed in converting the remainder of the charge into coke; and the worst results should naturally be expected from retort coke-ovens, such as the Bauer, at Ushaw Moor colliery, in which practically none of the coal itself is consumed, and the heat available for steam-raising is entirely derived from the gases driven off at a high temperature in the process of converting the coal into coke.

It may be assumed that the coal in question contains 77 per cent. of carbon capable of being manufactured into coke, and that the remaining 23 per cent. is volatile matter.

If the writer is correct in his opinion, the results obtained at Bowden Close colliery, are exceedingly unsatisfactory. The yield of coke in that yard is about 62 per cent. of the coal carbonized, hence 15 per cent. of coke must be consumed in addition to the volatile matter; and therefore, on the basis of 8 pounds of water per pound of coal burnt, the boiler should be evaporating 3·04 pounds of water per pound of coal coked instead of a trifle over 1 pound. The writer has no doubt, however, that the loss is due to the condition of the ovens themselves; they are very old, hence air is freely admitted in places where it ought not to be, and it is quite unreasonable under the circumstances to look for good results.

As to the Babcock-and-Wilcox boiler, at Stanley colliery, with ovens yielding in coke 66 per cent. of the coal carbonized, the

writer calculates that the water evaporated should be 2·72 pounds per pound of coal coked as compared with an actual evaporation of 1·78 pounds, and that at Esh colliery with ovens producing in coke 69 per cent. of the coal carbonized the evaporation should be 2·48 pounds as compared with an actual evaporation of 1·71 pounds. These results are, in the writer's opinion, satisfactory, and are not likely to improve, having regard to the fact that altogether apart from the loss by radiation (which is considerable) for quite 8 hours of each day, at least one-third of the ovens attached to the boilers are being unloaded and loaded, and that during the process cold air is freely admitted to the ovens and in fact to the main gas-flue; hence its temperature is for the time being decidedly reduced, and the evaporative power of the waste-heat is correspondingly lowered.

At Ushaw Moor colliery, the conditions are entirely different from those in the other yards to which the writer has referred. The boilers are working on modern retort-ovens of the latest description, recently erected, from which a yield of coke of 75 per cent. of the coal carbonized is being regularly obtained; hence he estimates that the waste-heat is capable of evaporating 2·000 pounds of water per pound of coal coked, as compared with an actual evaporation of 1·653 pounds. The results approximate very closely to the possible evaporation, but the writer is afraid that they will separate more widely as time goes on and the ovens become older and not so air-tight as they are now. The writer is inclined to think, however, that under ordinary circumstances the estimated and the actual results in water evaporated will be nearer in boilers fixed on retort-ovens than in those fixed on beehive-ovens, notwithstanding that part of the coal is consumed in the latter. The writer holds that opinion because retort-ovens are drawn more frequently than beehive-ovens: hence fresh rich gas is always being given off, the coke is cooled on the bench, the oven therefore retains its heat, and it is quickly loaded and closed up. To his mind, these advantages more than compensate for the additional heat derived from that portion of the charge which is consumed in the beehive-oven.

The writer ought to state that, at Ushaw Moor colliery, bye-products are not being recovered from the gas, and therefore it retains all its hydrocarbons and heat-producing qualities when it reaches the boiler. The writer would not expect, as a rule, to

evaporate more than 1 pound of water per pound of coal coked, from gas from which the bye-products had been extracted.

The results from the Lancashire boilers at Stanley colliery are decidedly low, the actual evaporation being only 0·849 pound of water as compared with a possible evaporation of 2·72 pounds. The figures are, however, not quite fair to the boilers, the test being taken over a comparatively short period, and better results are being obtained during certain portions of the day. Hence, to some extent, the figures are misleading and do not perhaps represent the average duty that the boilers are actually performing.

Similar boilers in other coke-yards are evaporating 0·75 to 1 pound of water per pound of coal coked, hence it may fairly be assumed that the boilers at Stanley colliery are giving results equal to those obtained elsewhere.

The method of attaching the Babcock-and-Wilcox boiler to coke-oven flues is exceedingly simple: it does not differ from the ordinary setting of such boilers, and in the writer's judgment there is the further advantage that less resistance is offered to the passage of the gases through the boiler to the chimney than in any other class of boiler with which he has had experience except perhaps the egg-end. Hence the draught of the ovens is not appreciably affected, and uniform burning is secured with the minimum of trouble in the matter of regulating the flue-dampers.

In conclusion, the writer would add that the only object he had in view in communicating these notes and observations to the members was to direct attention to a matter of considerable importance to coke-makers, more especially as it seems likely that the manufacture of coke will in the near future be more or less carried on at most collieries, perhaps not altogether for the purpose of obtaining coke but in order to utilize inferior coal and to recover therefrom the bye-products which it contains.

When that time comes, the question of firing boilers with waste-heat from the ovens will assume even greater importance than attaches to it now; unless, as seems not unlikely, gas-engines supersede, to a large extent, the steam-engines in universal operation to-day.

Mr. A. L. Steavenson wrote that Mr. Greener's paper afforded much useful information. There did not seem to be much difference in favour of any one of the boilers more than the others, the five-flued boiler and economizer at Esh colliery standing highest. In such a critical test, he thought it would be useful to know how the capital expenditure compared, including the cost of the economizers; and whether both kinds of boilers would stand the work for 20 years, on which point, he was inclined to prefer the Lancashire boiler. The value of the coke-oven gas, apart from the sensible heat, in work done, was information much wanted. Members were told, very often, that so many thousand cubic feet of gas, with a calorific power of so many British thermal units, were produced, but he (Mr. Steavenson) wanted to know how many cubic feet of such were required to boil a pound of water.

Mr. Gerald H. J. Hooghwinkel (London) wrote that Babcock-and-Wilcox, Stirling and five-flued boilers were improvements on Lancashire and antiquated egg-ended boilers, because of their better heat-abstracting qualities, as shown by the comparatively low temperatures of their flue-gases. These boilers also did not require economizers to be attached, but the chimneys should be much higher. The results of Mr. Greener's tests shewed that the draught was too high for the Lancashire boilers.

For bee-hive coke-ovens, without bye-product recovery-plant, a water-tube boiler was the best steam-producer; but, with modern bye-product coke-ovens, the intermediate use of steam should be abandoned, and the cleaned gases should be used direct in gas-engines. This had been done for some years on the Continent, notably in Germany, and it was now incorrect to say that this means of power-production was still in the experimental stage. The writer had been connected with the installation of many thousands of horse-power; and, after the usual preliminary deceptions, due to insufficient knowledge of the composition of the waste-gases, no trouble had been experienced.

The question of cleaning the waste-gases and the proper size of this cleaning plant and gas-engine plant constituted so many interesting questions, which, however, had been solved to the entire satisfaction of gas-engine experts.

The quantity of the gases given off depended entirely on

what coal was being coked, and on the construction of the coke-ovens, and varied accordingly.

Mr. Robt. Peel (New Brancepeth Collieries) wrote that his experience agreed with Mr. Greener's, with regard to the efficiency of the water-tube type of boiler at coke-ovens, and its superiority as a steam-generator to the Lancashire boiler. There was no difficulty in erecting water-tube boilers to utilize gases from coke-ovens; and that in such a manner that the draught of the coke-ovens would not be affected by the passage of the gases through the boilers, more than in the case of any other class of boiler. Moreover, they were readily accessible for inspection and cleaning. Good water, however, was desirable, otherwise the boilers would require to be laid idle frequently, in order to clean the tubes. If this occurred during working hours, considerable inconvenience and loss might arise in consequence of an inadequate supply of steam to the colliery-engines.

At New Brancepeth colliery, about 3 years ago, two egg-ended boilers, 45 feet in length and 5 feet in diameter, were replaced by two Babcock-and-Wilcox boilers. These have 100 tubes, each 4 inches in diameter and 18 feet in length. The gas from 38 bee-hive coke-ovens, 11½ feet in diameter, is passed through these boilers. No trouble has been caused by the tubes, and the results have been so satisfactory, that recently three more boilers have been installed. These have been erected to utilize the heat from the waste-gases of 40 Otto-Hilgenstock coke-ovens, from which bye-products (sulphate of ammonia and tar) are recovered. These boilers have each 126 tubes, 4 inches in diameter and 18 feet in length, each yielding 2,852 square feet of heating surface.

Evaporative tests have shown that 0·67 pound of water is being evaporated per pound of coal carbonized in the ovens. When compared with the results obtained at Ushaw Moor colliery, this result seems very low: the water evaporated at that colliery, per pound of coal coked, being 1·476 pounds. It must, however, be remembered that, at the latter colliery, the bye-products are not recovered, and that, therefore, the gases going to the boiler contain all the hydrocarbons, the combustion of which, in passing along the flue and through the boiler, would

increase the amount of heat and, consequently, evaporate more water.

The result at New Brancepeth colliery is also lower than Mr. Greener anticipates, when the bye-products are recovered. He says that he would not expect, as a rule, to evaporate more than 1 pound of water, per pound of coal coked, from gas from which the bye-products had been extracted. The deficiency may (to a large extent) be accounted for by the fact that at present all the gas from the 40 coke-ovens is not passed along the flue to the boilers. More gas is available than is required to heat the flues of the coke-ovens to the proper temperature, and this surplus gas is at present being burnt in the open air from a pipe at the end of the ovens. As soon as this gas is carried into the main flue, a larger quantity of water will be evaporated, and the results probably will approximate more nearly to Mr. Greener's estimate. There is, however, for the time being, an ample supply of steam for the requirements of the colliery from the various boilers at the coke-ovens.

Mr. W. C. Blackett (Sacriston) wrote that the consumption of coal by collieries must, of course, depend on the work to be done, and it was quite possible that one colliery might be doing better work with a consumption of 2 per cent., than another with even so low a consumption as 1 per cent. The depth of winding, the distances of haulage underground, and, more especially, the quantity of water to be pumped, were factors which rendered comparisons difficult. So far as his experience went, by far the best boilers for coke-ovens were those of the water-tube type, as they were superior to Lancashire boilers and did not require to be supplied with better water; indeed, with equal water, the water-tube boiler, and particularly the Babcock-and-Wilcox, was even safer, provided that copious and frequent sludging was resorted to, along with suitable chemical treatment of the water, where necessary.

About 2 years ago, at Kimblesworth colliery, two Lancashire boilers, each 30 feet long and 8 feet in diameter, were applied to 40 coke-ovens, measuring 11 feet by 10 feet, fitted with an arrangement for burning with hot air. These coke-ovens each produce 10½ to 11 tons of coke per week, being a yield of about 69 per cent. of the coal. Excellent results were obtained from these two boilers, 1·45 pounds of water at 212° Fahr., being

evaporated per hour per pound of coal coked, and 5·4 pounds per square foot of heating surface, and he might well have been satisfied, especially in the light of Mr. Greener's figures with both Babcock-and-Wilcox and five-flued boilers.

TABLE II.—PARTICULARS OF EVAPORATION-TESTS OF BOILERS ATTACHED TO COKE-OVENS AT THE UNDERMENTIONED COLLIERIES.

Name of colliery ...	Kimblesworth.	Kimblesworth.	Sacriston.
Class of boiler ...	Two Lancashire.*	Two Babcock-and-Wilcox.	Six Lancashire.§
Duration of tests ...	—	168 hours continuous	—
Average temperature of flue-gases at back of boiler ... degs. Fahr.	750	381	700
Average water-gauge at chimney inches	0·35	0·50	0·45
Average temperature of feed-water entering boiler ... degs. Fahr.	125	142	130
Average pressure of steam per square inch pounds	60	150	70
Coals coked per hour ... ,,	8,300	8,316	22,000
Water evaporated per hour ... ,,	10,800	16,070	28,000
Water evaporated per pound of coal coked ,,	1·300	1·935‡	1·320
Water evaporated per hour per pound of coal coked, assuming the temperature of the feed-water at 212° Fahr. ... pounds	1·45†	2·17†	1·42†
Water evaporated per square foot of heating surface of boiler ... pounds	5·40	3·56	5·35

* Two Lancashire boilers, each 30 feet long and 8 feet in diameter, with 1,000 square feet of heating surface, fired by 40 coke-ovens.

† From and at 212° Fahr.

‡ Each boiler was sludged six times in the 24 hours, and 2·4 per cent. of the total evaporation was blown off. If this loss were neglected, the evaporation would be 1·98 pounds per pound of coal coked.

§ Each with 900 square feet of heating surface

However, he ascertained that the heat escaping into the chimney was still very high, and although the boilers were new, they were replaced by Babcock-and-Wilcox boilers, and the results had quite justified this change. The Babcock-and-Wilcox cost, with setting, about £640 each; and they were evaporating (at 212° Fahr.) the somewhat extraordinary quantity of 2·17 pounds of water per pound of coal carbonized, and the temperature of the gases in the chimney was reduced to about 381° Fahr. The steam had a pressure of 150 pounds per square inch, and it was used through a reducing-valve, the superheat helping to dry the steam, when used at a lower pressure. The water-gauge, on the chimney, was less than ½ inch. The excellence of these results is doubtless due to the fact that comparatively little heat is wasted by flue-and-oven radiation, and to ample room being

provided for the flow of the heated gases; but much also must be attributed to the quality of the coal carbonized, which was similar to that coked at Esh colliery. The Busty seam produces a high-class coal, the volatile matter varying from 26 to 27 per cent.; but, on the other hand, little carbon was wasted, as the coke-yield was 69 per cent. when the ovens were at their best.

He agreed with Mr. Greener that the results at Bowden Close colliery were low, but he did not anticipate that 3·04 pounds of water could be boiled per pound of coal coked. He (Mr. Blackett) agreed that Lancashire boilers, when hand-fired, would regularly evaporate 8 pounds, but it was not fair to assume, because 38 per cent. of the coal was consumed in carbonizing, that this heat was available at the boiler, and that the result of 38 per cent. of 8 pounds (3·04 pounds) could be obtained. Heat was used for heating the cooled oven-walls, for lighting the charge, for driving off moisture, and wasted by radiation from the flues, etc., so that he (Mr. Blackett) was inclined to think that the results at Kimblesworth colliery, when compared with 8 pounds, were as high as could be obtained, as they got 2·17 pounds out of the theoretical result of nearly 2·48 pounds, that is, 31 per cent. of 8 pounds.

On the other hand, however, it was questionable whether 8 pounds was a proper figure to take, as it was produced by Lancashire boilers; he (Mr. Blackett) thought that the result of the Babcock-and-Wilcox boilers ought to be taken, and this, at Kimblesworth colliery, was about 12 pounds, as ascertained by hand-firing for experimental purposes before the coke-oven heat was employed. The evaporation was 2·17 pounds instead of 3·72 pounds, if all the heat was available at the boiler. This was above 58 per cent., while Bowden Close gave about 23½ per cent. by this latter method of comparison.

At Sacriston colliery, where the boilers are the same as those at Stanley colliery, 1·42 pounds of water are evaporated for 1 pound of coal coked, so that the boilers at Stanley colliery give results considerably below these. The evaporation per square foot of heating surface is 5·35 pounds; twenty ovens being attached to each boiler.

Mr. M. Deacon (Chesterfield) wrote that Mr. Greener stated "that it is quite practicable . . at a colliery equipped with

the most modern appliances, to produce all the steam required without burning more coal than 1 per cent. of the output." Whilst this may be so under exceptional conditions, where the depth of the winding-shaft is not great and mechanical haulage and pumping are not important items, or where a considerable amount of power is obtained from waste-gases from coke-ovens, he (Mr. Deacon) did not think that a lower consumption than $2\frac{1}{2}$ per cent. could be attained, unless of course the power were obtained by means of waste-gases, or producer-gas utilized in gas-engines.

With regard to the best type of boiler to be used in connection with coke-ovens, given good water, there was no question that the tubular boiler of the Babcock-and-Wilcox or other similar type would evaporate more water and utilize the waste-heat to better advantage than the Lancashire boiler; but, in the case of indifferent water, the use of this type of boiler was questionable.

The question of the evaporative power of the Babcock-and-Wilcox and other tubular boilers as compared with the Lancashire boiler in relation to the capital outlay was, however, a matter which required close consideration, and it would be interesting if Mr. Greener would give the members a comparison of the cost of each kind of boiler per 1,000 gallons evaporated. It would probably be found that there was not much difference between the two costs.

Mr. L. T. O'Shea (University College, Sheffield) thought that the members were under a debt of gratitude to Mr. Greener for bringing before them a subject on which they had received, hitherto, a very small amount of information. The uses of these gases for the generation of steam was a subject of considerable importance, and he had taken some interest in it of late, especially with regard to the use of the gases from bye-product coke-ovens. It seemed to him that the results set forth by Mr. Greener in his paper were exceedingly favourable, and although they fell below the theoretical calculation for the amount of water evaporated, the members should remember that a large portion of the heat of these gases was used in coking the coal; and, therefore, when results as high as those obtained by Mr. Greener were recorded, they saw that a very profitable source of energy was available.

With regard to the use of the gases from bye-product coke-ovens, the results at Ushaw Moor colliery were very good, but they must take into consideration the fact that the bye-products were not recovered, and consequently that the gases going to the ovens were only in a partly burnt state, and therefore they were obtaining from the gases, under the boilers, heat for the generation of steam in addition to the heat which the gases carried owing to their temperature. But the conditions were entirely different when coke-ovens used for the recovery of bye-products were considered. In their case, a large portion of the heat-producing substances in the gases had been recovered and removed with the bye-products, and only a portion was burned in the flue for the production of coke. It was this portion of the gases, after being burned in the flues, which was taken for the generation of steam; and a large portion of the gases which would be available for the generation of steam or the making of coke was not recovered, and therefore as a rule was burned to waste. Consequently he (Mr. O'Shea) feared that when members made experiments on the value of these gases from bye-product coke-ovens for the generation of steam, they would find that they did not obtain anything like the results recorded by Mr. Greener in his paper, because the gases burned in the oven-flues were completely burned before reaching the boilers, and only raised steam through their cooling but not by means of combustion.

It would be interesting to have results as to the efficiency of gases from bye-product coke-ovens in the manner in which they were now used, especially in regard to the question of heating the air used for combustion. If the waste-gases were used, before they came to the boiler for raising steam, for heating the air before that air was used for combustion in the flues, there was at the same time taken from them a certain amount of heat which would otherwise be utilized in the generation of steam.

It seemed to him that Mr. Greener's concluding remarks in his paper should be carefully considered by coke-manufacturers, as to whether it would not be more profitable to use the gases in gas-engines, rather than through the intermediary of steam: because, as Mr. Greener had mentioned, a large proportion of the gases from the bye-product plant could not be used in the oven-flues.

Mr. C. C. LEACH (Newcastle-upon-Tyne) said that Mr. Greener compared the latest type of boiler (the Babcock-and-Wilcox) with an obsolete one in the tests at Stanley colliery, and the results seemed more or less variable. The old Lancashire boiler was only 7 feet in diameter and was quite out of date (9 feet would be the diameter of a modern boiler); the heat for making steam was the heat left after warming all the iron to the necessary temperature; and in the small boiler there was a larger relative proportion of iron to be heated than in the large boiler of the present day. Again, the chimney for the Babcock-and-Wilcox boiler was 106 feet high and 6 feet square, while the two Lancashire boilers had a chimney 130 feet high and 7 feet square; and probably the smaller chimney coupled to the Lancashire boiler would have given the most efficient result. He (Mr. Leach) had in his mind a case where a new chimney was built: the coal-consumption immediately rose by leaps and bounds, and it was not reduced until the damper was lowered, and the water-gauge was reduced. Again, the heating surface of the Babcock-and-Wilcox boiler was 2,823 square feet, and that of the two Lancashire boilers was 1,788 square feet, yet the temperatures of the flue-gases were the same: where was the extra heat lost. Yet again, the members were told that the Babcock-and-Wilcox boiler was evaporating 9,432 pounds of water as compared with 4,500 pounds of water per hour by the two Lancashire boilers. He thought that these results required further investigation, as he understood that water-tube boilers evaporated very little more water than a good Lancashire boiler, and he would like to know whether any test had been made to ascertain how much water primed over with the steam in the case of the Babcock-and-Wilcox boiler. For every pound of water primed over with the steam, about 1,000° of heat was saved out of about 1,300°, so that an erroneous result might be obtained: water-tube boilers were noted for priming. He (Mr. Leach) had not yet lost faith in the Lancashire boiler, but he liked to use one of proper dimensions.

Mr. PHILIP KIRKUP (Birtley) asked what quality of water was used. It was of great importance with water-tube boilers that good water should be supplied, but colliery-boilers, generally, were supplied with bad water. He asked whether the tubes of

the Babcock-and-Wilcox boiler were readily accessible. It seemed to him that the occurrence of burst tubes would be a serious matter in the main flue of a range of coke-ovens. He asked whether the five-tubed boiler had its flues so arranged as to be efficiently fired, that is, was the boiler flash-fired or the gases coursed round in the usual way of hand-fired boilers; and were they fitted with cross tubes as in ordinary Lancashire boilers.

Mr. James S. Dixon (Bothwell, N.B.), speaking from 20 years' experience of Babcock-and-Wilcox boilers, said that the point raised by the previous speaker was very material. It was absolutely necessary to have good water, free from acid, and as far as possible free from lime or scale. The tubes of the Babcock-and-Wilcox boiler, when thickened by scale, were apt to crack, and the joints at their ends gave trouble if any acid was present. In these days of water-softening plants, and arrangements for saving condensed water, however, all these difficulties could be overcome. A turbine-arrangement (a simple appliance driven by steam or the feed-water) could be used in Babcock-and-Wilcox boilers; put on the end of a hose and run through the water-tubes, it removed all scale, leaving the tubes perfectly clean.

Mr. S. F. Walker (Bath) thought, after studying Mr. Greener's paper, that it was necessary to ascertain the number of cubic feet of gas given off per ton of coal and the composition of the gas, because the composition of the gas had a very important bearing on its calorific value and the quantity of water evaporated by it. Coke-oven gas had a high calorific power, dependent upon the percentage of the contained marsh-gas and hydrogen. The gases from the Simon-Carvès coke-ovens at the Wharncliffe Silkstone colliery had a calorific power of 365 British thermal units per cubic foot.* At Whitworth colliery, the gases from the closed retort-ovens had the high calorific power of 550 British thermal units per cubic foot.

The common idea was that the gas could be better utilized in the gas-engine: consequently, it was necessary to know the quantity of gas which could be drawn from the coke-ovens. Taking 10,000 cubic feet as the product of a ton of coal, he

* *Trans. Inst. M. E.*, 1905, vol. xxix., page 191.

calculated that Mr. Greener had got as good results as if the gas had been scrubbed and utilized in a gas-engine. The whole question, therefore, resolved itself into one of figures, and measurements should be taken all the way along and checked so as to see how they came out in the aggregate. Mr. Lozé, in his paper, stated that at the Lens collieries, in France, instead of coking the cheap coal, a suction gas-producer plant had been erected, and the power-gas utilized in a gas-engine. Ordinary producer-gas had a calorific value of 140 British thermal units, and it was said that economical results could be obtained in that way. Mr. Greener had referred to the unequal production of heat, because of the ovens being drawn and loaded during the daytime. There were two methods of getting over that difficulty: (1) storing the gas and scrubbing it, and (2) the thermal storage-system, by which the heat of the gas was stored in water of whatever temperature they pleased, and was utilized afterwards for feed-water.

Mr. Roslyn Holiday remarked that the advantage of the water-tube boiler was that gas could be introduced at the underside, practically into the firing-chamber, instead of introducing it from the firing doors, leaving the hand-firing place available for use, when necessary. He suggested that it might be possible to bring in the coke-oven gases, and during the daytime to use low-class fuel, such as the mud from the washer, to heat up the gases, and so overcome the difficulty. It was a great advantage to be able to fire by hand, when necessary.

The Chairman (Mr. H. C. Peake), in proposing a vote of thanks to the writer of the paper, said that he had had no experience in coking, but he recognized the fact that great savings in coal-consumption could be effected by utilizing the waste-heat from the coke-ovens.

Mr. S. F. Walker seconded the resolution, which was cordially approved.

Mr. M. R. Kirby's paper on "The Compound Winding-engine at Lumpsey Mine" was read as follows:—

THE COMPOUND WINDING-ENGINE AT LUMPSEY MINE.

BY M. R. KIRBY.

Old Plant.—Some time ago it was decided to renew the power-plant at the Lumpsey mine, with a view to reducing the coal-bill. The old plant, consisting of six egg-ended boilers, supplied steam, at a pressure of 40 pounds per square inch, to non-condensing engines, driving the winding, hauling, pumping and ventilating machinery, and the dynamo used in connection with the electric drills.

New Plant.—The old plant was replaced by three Lancashire boilers, 8½ feet in diameter and 30 feet long, fitted with a Green economizer, and working at a pressure of 150 pounds per square inch, supplying steam to the winding-engine (which was converted into a cross-compound) and to a set of four steam-generators of 200 horsepower, with compound double-acting high-speed engines, and compound-wound dynamos, supplying continuous current at 240 volts to motors driving the rest of the machinery. The whole of the exhaust-steam from these engines is condensed in a barometric jet-condenser, having steam-driven air and circulating pumps. The arrangement of the new plant, which was in a large measure determined by the configuration of the ground, is shown in Fig. 1 (Plate XII.).

Winding-engine.—The winding-engine was originally a double-horizontal engine, having two cylinders, 42 inches in diameter by 6 feet stroke, with Cornish valves; and a conical drum, from 17 to 21 feet in diameter, on the crank-shaft. It was built in 1881, and, after having run for over 20 years, was practically unworn. This engine was converted into a cross-compound by replacing one of the original cylinders with a high-pressure cylinder, 24 inches in diameter with Corliss valves,

and putting in a receiver having a capacity equal to twice that of the low-pressure cylinder. Two throttle-valves were fitted, one between the main steam-pipe and the high-pressure cylinder, and one between the receiver and the low-pressure cylinder, both being worked by one handle. A reducing valve, 1½ inches in diameter, was provided, on the main steam-pipe, to maintain the receiver-pressure during long stands. The effect of this arrangement is to make the engine handle in exactly the same manner as a double engine, and also to keep the high-pressure cylinder and receiver hot between winds. The general arrangement of the engine is shown in Figs. 2 and 3 (Plate XII.).

The winding-engine with condensing plant was completed in 1903, before the generator-engines were ready, and the opportunity was taken to make steam-consumption trials under ordinary working conditions. The results of three of these trials are given in Table I.

The steam-consumption appears, to the writer, to be exceedingly low, especially when the indicator-diagrams shewn in Figs. 4, 5, 6 and 7 (Plate XIII.) are considered. It will be seen from these that there is no expansion in the cylinders, and that there is considerable back-pressure in the low-pressure cylinder, the inlet to which is throttled.

Little advantage was gained by using the condenser, but it must be remembered that this was designed to condense the steam from the generator-engines, as well as from the winding-engine, and, during the test, it was working at a very great disadvantage.

The results of trials of two double-horizontal winding-engines are also given in Table I., and indicator-diagrams taken from them are shewn in Figs. 8, 9, 10, 11, 12, 13, 14 and 15 (Plate XIII.).

Description of Winding-engines.—The Lumpsey winding-engine has horizontal cross-compound condensing cylinders, 24 and 42 inches in diameter by 6 feet stroke. The high-pressure cylinder is fitted with Corliss valves; the low-pressure cylinder with Cornish valves; and both with Allan straight-link reversing-gear. The conical drum, 17 to 20 feet in diameter, is fixed on the crank-shaft.

The Park winding-engine has two horizontal non-condensing

cylinders, both 32 inches in diameter by 5 feet stroke. The balanced slide-valves are fitted with Stephenson reversing-gear. The drum, 9 feet in diameter, is fixed on the crank-shaft. This engine was in poor order when tested.

TABLE I.—Results of Tests of Winding-engines.

Name of mine	Lumpsey.			Park.	Skelton.
Depth of shaft .. feet	590	590	590	400	125½
Date of test ... 1904	March 11	March 25	April 12	—	—
Duration of test ... ... hours. min.	8 10	8 30	8 40	9 45	8 30
Mean steam-pressure per square inch pounds	130	130	135	43	45
Vacuum ... ... inches	25	26	none	none	none
Condenser	working	working	standing	none	none
Economizer	standing	working	standing	none	none
Temperature of water entering hot well ... degs. Fahr.	—	60	—	—	—
Temperature of hot well degs. Fahr.	—	92	—	—	—
Temperature of feed-water to boilers ... degs. Fahr.	—	210	—	40	100
Stone raised ... tons	1,774	1,685	1,742	1,639	454*
Winds with stone No.	567	528	553	530	315†
Winds with men, etc. No.	—	—	—	72	34
Coals used ... pounds	8,176	7,280	9,968	10,549	550
Ashes and clinkers from furnace ... pounds	—	—	—	1,655	—
Steam used do.	59,840	62,458	61,941	79,156	4,156
Time of wind with stone seconds	27	26	27	27	11
Indicated work of engine horsepower	1,557	—	—	935	68·6
Actual horsepower-hours performed	1,184·0	1,125·0	1,162·0	741·7	53·5
Steam used per actual horsepower-hour ... pounds	50·50	55·50	53·00	108·07	77·70
Coal used per actual horsepower-hour ... pounds	6·90	6·47	8·50	14·20	10·28
Water evaporated per pound of coal pounds	7·30	8·50	6·20	7·50	7·50
Ash and clinker in coal ... per cent.	—	—	—	15·6	—
Time running in shaft with stone per cent.	52·0	45·0	48·0	40·7	9·4
Mechanical efficiency do.	76·0	—	—	79·2	78·0
Steam per indicated horse-power-hour pounds	38·4	42·2	40·3	85·6	60·6

* Comprizing 364 tons 17 cwts. of stone raised, 125½ feet, from the shaft-bottom; and 89 tons 8 cwts. raised, 17 feet, from the horse-hole.

† 242 winds from the pit-bottom and 73 winds from the horse-hole.

The Skelton winding-engine has two horizontal non-condensing cylinders, 15½ and 15⅝ inches in diameter respectively by 3

feet stroke. The slide-valves are fitted with Stephenson reversing-gear, run in three-quarter gear. The drum, 8 feet in diameter, is geared as 2·46 to 1 to the crank-shaft.

Method of Testing.—The feed-water was measured, in the case of the Lumpsey winding-engine, by means of a counter on the feed-pump, the capacity of which was frequently checked by a measuring tank; and, in the other cases, the water was measured in tanks.

The steam-consumptions given are the total feed-water, and include the steam used for all other purposes, together with condensation and leakage. The developed power of the engines is expressed in actual horsepower-hours and is found by the formula:—$(W \times D) \div (33{,}000 \times 60)$; in which W is the total weight raised in pounds; and, D, the depth of the shaft in feet.

The coal used was of about the same quality in all cases, and contained 12 to 16 per cent. of ash and clinkers. It was weighed on accurate scales.

All the tests were made under ordinary working conditions.

Conclusion.—In conclusion, the writer would say that, in his opinion, a properly designed winding-engine, on the same principle as that at the Lumpsey mine, would not use more than 35 pounds of steam per actual horsepower-hour, when running non-condensing. Further, that a very low figure indeed would be obtained by using a three-cylinder triple-expansion condensing engine, with three cranks at angles of 120 degrees, a fixed cut-off, and direct-driven air and circulating pumps.

Mr. JOHN McLAREN (Leeds) wrote that some years ago he had the honour to submit a paper to the members on "The Economical Use of Steam in Colliery-engines."* He was glad that other engineers were turning their attention to this important subject, as he believed that it would be greatly to the advantage of the coal-trade generally if more of these tests were made, and the results discussed with a view to increased economy in the use of steam, which is synonymous with economy of fuel. Judging by what one saw and heard in the neighbourhood of

* *Trans. Inst. M. E.*, 1891, vol. ii., page 344.

coal-mines, in the clouds of steam exhausted into the atmosphere with a noise audible at a distance of several miles, one might be pardoned for assuming that economy of coal in the operations aboveground and belowground was not of the slightest consequence.

The paper written by Mr. Kirby was valuable, inasmuch as it threw some light on a rather obscure branch of practical engineering; and, though he could not agree with the writer that the results were at all satisfactory, he thought that his figures were important as calling attention to the huge waste which goes on with ordinary engines such as are in use at the Lumpsey mine, not to speak of the extravagance of indifferent and wasteful engines like that at the Park mine, where the enormous steam-consumption of 85·6 pounds per indicated horsepower was noted. When the majority of the well-made engines used for marine and industrial purposes required from 11 to 13 pounds of steam per indicated horsepower, it seemed extraordinary that a consumption of 38 to 42 pounds per indicated horsepower in a colliery winding-engine should be tolerated; while, with regard to the Park engine, he had no doubt that the fuel wasted there would have been sufficient to purchase a new well-made and economical winding-engine about every second year.

He (Mr. McLaren) proposed to confine his remarks to the Lumpsey engine, and he thought it was regrettable that no record was kept of the steam used for "other purposes." It was not fair to debit the winding-engine with an unknown quantity of steam which might have been required for auxiliary plant; but he assumed that the quantity was inconsiderable, or the writer would have made some attempt to apportion the relative amounts of steam absorbed by the winding-engine and that used for "other purposes." It was unnecessary to state that all engine-tests, to be of any value, must be strictly accurate, and the engine must be debited with everything which fairly belonged to it; but, in this case, steam to an unknown amount had been used for "other purposes," and charged to the winding-engine. The absence of steam-traps, by which the condensation in the long range of steam-pipes and the large receiver might have been ascertained and recorded, was rather unfortunate; because, if this had been deducted, it would probably have made an appreciable difference in the steam-result.

The indicator-diagrams were interesting, but they did not at all account for the enormous steam-consumption, and, moreover, they would have been much more valuable had they been taken simultaneously with four indicators, one at each end of each cylinder, with one and the same load, rather than at different times with different and varying loads, and they afforded no means of forming an opinion or making a comparison.

It appeared late in the day to advocate the use of condensing engines for nearly all the steam-plant about a colliery, particularly for the winding-engines, as the immense volumes of steam exhausted into the atmosphere constituted just the sort of waste which exasperates an engineer. It was a valuable residual which could be very simply utilized by means of the condenser.

There was an incomprehensible feature in the data given in Table I. The actual horsepower-hours did not vary much in the three tests (1,184, 1,125 and 1,162), equal to about 5 per cent. of extreme variation. The total steam used and the steam used per indicated horsepower varied in a somewhat similar ratio, but the coal-consumption varied enormously (8,176, 7,280 and 9,968 pounds), equal to nearly 40 per cent. of extreme variation. The last figure, as applied to coal only, would have been explained by the absence of the condenser, which was not working on this particular test, if the water used had risen in the same proportion as the fuel; but, in this case, the steam-consumption per indicated horsepower was an exact average of the three trials, whereas the coal-consumption was 17·6 per cent. above the average.

He (Mr. McLaren) was inclined to think that there must be some error in Mr. Kirby's figures with regard to the coal and steam used in the third non-condensing test, as it was contrary not only to reason, but to experience, that the steam-consumption per indicated horsepower should be practically the same when working on the atmosphere, as when working condensing with a vacuum of 25 to 26 inches of mercury, as in the first two tests. Apart from this, however, the writer's figures showed that (unless his experience was unique) there was still room for enormous improvements in the steam-plants in use about collieries, and he (Mr. McLaren) suggested that wherever possible similar tests should be made elsewhere, and the data

carefully recorded, and laid before the members for their information.

Mr. S. L. THACKER (Walsall) wrote that the value of Mr. Kirby's paper would have been considerably enhanced had the data been supplemented by details of the masses to be set in motion in addition to the net load, the maximum velocity during the wind, with the periods of acceleration, full speed and retardation. In the absence of this information, it was not possible to calculate the kinetic energy in the moving masses and the formula (W × D) might give the total work per wind or it might give a quantity considerably less.

As he (Mr. Thacker) had endeavoured to shew in his paper,* unless the cut-off of the steam to the engine was manipulated with great care, so that the kinetic energy was exactly utilized to complete the wind during the period of retardation, without the application of the brake or of back-pressure in the cylinders, it was entirely fallacious to regard the work of raising the unbalanced load as being the actual effective work of the winding-engine. The same mistake had been repeated in almost all the tests of winding-engines recorded in the *Transactions*, and they were entirely inconclusive in regard to the relative merits of the engines themselves.

The figures given in Table I. were of course the results of tests, not of the engines themselves, but of the complete winding-plants, and only in that sense could any comparison be made. Nothing could better illustrate the force of his contention than the figures for the mechanical efficiency, giving a higher efficiency for the Park engine in poor condition than for the Lumpsey improved compound engine. This was probably due partly to the higher ratio of the net load to the total mass in the case of the Park engine, and partly to the larger and heavier drum of the Lumpsey engine.

It was interesting to note that the highest steam-consumption of the three tests of the compound engine was obtained when the percentage of the time of actual winding was lowest, shewing that condensation in the steam-pipes, etc., was a material factor: for the same reason, it was not conclusive that no advantage

* "The Dynamics of the Winding-engine," *Trans. Inst. M. E.*, 1903, vol. xxvi., page 445.

was obtained by using the condenser. In the case of an intermittently running engine it hardly seemed fair to debit the steam-consumption with the whole condensation while standing, and it had occurred to him (Mr. Thacker) whether a meter might not be used to measure the cubic feet of steam passing in the steam-pipe, but the difficulty was to compensate for the relative wetness or dryness of the steam.

He (Mr. Thacker) would like Mr. Kirby to explain why in the case of the Lumpsey engine, the lowest coal-consumption was obtained with the highest steam-consumption, and the highest coal-consumption with the mean steam-consumption. The time and labour expended in carrying out these tests must have been considerable and he hoped that Mr. Kirby would furnish the supplemental data he had suggested, when it might be found that the compound engine would give even still better comparative results.

Mr. B. Woodworth (Longton, Staffordshire) wrote that the Lumpsey winding-engine had been provided for an extremely short run, probably between 10 and 11 revolutions only per wind. He could appreciate the arrangement for cross-compounding the engine, the large receiver-provision being a necessity, but he was surprised that the steam-admission had not been reduced to at least 85 per cent. of the full stroke, as the engine would have been quite as easy to work, and the efficiency would have been as good or even slightly better, combined with considerable economy. The times of running in Table I., would be the running time in the shaft from start to stop: probably the time under steam would be over 10 seconds less, and the actual time under steam would probably be about 30 per cent. only of the full working time. The mechanical efficiency was very high for this class of work, and it appeared possible that some error had crept in on this head.

The valve-arrangements of the Park winding-engine were evidently a little better than in the case of the Lumpsey engine, and the run was considerably longer, but there was a reaction from the exhaust of the opposite cylinder shewn on the whole of the diagrams.

The Skelton engine had a very fair distribution and utilization of the steam, the exhaust and compression would suit a

good speed of working, and the major portion of the saving over the Park engine was due to the better utilization of the steam in the cylinders, leaving the balance to the debit of the bad conditions under which the Park engine was working.

The loads all round were very lightly proportioned, the starting loads being only about 16 to 18 pounds per square inch on the average on the original cylinders, and consequently there was ample power-margin all round; but, to get the stated mechanical efficiency, the engine would need extremely careful handling with a total absence of loss by brake or reversing action, and even then it would in his (Mr. Woodworth's) opinion be hardly possible to obtain it.

Mr. M. Deacon (Chesterfield) wrote that Mr. Kirby's concluding remarks with regard to a suggested steam-consumption of 35 pounds per actual horsepower-hour, when running non-condensing, with an engine similar to the Lumpsey engine, was hardly compatible with the tests recorded in the paper, which indicated 50 pounds and upwards with a vacuum of 26 inches; and he (Mr. Deacon) did not think that under ordinary conditions of winding, in which considerable condensation must take place in the cylinders when the engines were standing, that such a low consumption could be reached. He had non-condensing winding-engines working under favourable conditions, that was, with very short intervals between the winds, in which the steam-consumption did not materially exceed 50 pounds per indicated horsepower-hour, and he doubted, very much, whether this could be materially reduced, under ordinary conditions, when winding from moderate depths. A well-designed engine winding from great depths, with high-pressure steam, and trip-gear, would no doubt produce better results, probably as low as 40 pounds, but he did not think that this result could be attained with so moderate a depth as that of the Lumpsey shaft.

Comparing the Lumpsey with the Skelton engine, there appeared to be a saving in the former of about 20 pounds per indicated horsepower-hour, but the comparison was not made on parallel lines, since the proportion of stoppages to the time of winding must of necessity be greater in the Skelton engine, owing to the lesser depth of the shaft. Probably under precisely similar conditions, there would not be more than 10 pounds difference in the steam-consumption of the two engines.

It would be interesting if Mr. Kirby would indicate, in money, the economy per annum that he had obtained in fuel-consumption at the Lumpsey engine, and compare this with the interest on the capital and the depreciation on the additional cost of a compound condensing-engine, as contrasted with a high-pressure engine.

Mr. T. C. Futers (Broomhill) thought that Mr. Kirby's paper was a valuable one, inasmuch as it afforded reliable information concerning the actual steam-consumption in a winding-engine. Ordinarily, it was a difficult matter to obtain this information with any degree of accuracy, as usually steam was drawn from a common range of boilers, which supplied steam to other engines.

It appeared to him (Mr. Futers), however, that an opportunity had been neglected to put down a good engine; and, judging from the indicator-diagrams, the valve-gear was bad and the pipes too small. In all probability these might have been re-designed and applied at the same time as the new cylinder at a little extra cost, and with certainly very advantageous results. It was unfair, however, to credit the engine with all the saving effected in steam-consumption, as this was undoubtedly due to the higher steam-pressure; and if the old engine had been supplied with high-pressure steam, or if either the Park or Skelton engines were to be supplied with steam at 130 pounds instead of 43 or 45 pounds per square inch, the consumption would, in his opinion, be very considerably reduced, provided they could be worked with a high expansion. In all probability where compound engines were installed, and credited with a reduction of steam-consumption, the actual saving was not due so much to the engine as to the fact that the steam-pressure had been raised, and consequently more calorific value had been obtained from the coal. It was evident that the compound engine was not superior in mechanical efficiency to either the Park or the Skelton winding-engines, as the former was admittedly in bad order when tested.

It had always been a moot point as to whether the installation of a condensing-plant for a winding-engine was worth the capital outlay; that was, would the amount of steam saved by condensing be more than sufficient to drive the air and cir-

culating pumps, cover the upkeep and the depreciation of the plant, and yet yield a fair interest on the capital expended? At most collieries where the fuel used was of little value, he (Mr. Futers) thought that it would not. It would be interesting to hear what was Mr. Kirby's experience with the condensing-plant and the actual results of the saving effected by it, as soon as it was working to its full advantage.

Mr. C. C. LEACH (Newcastle-upon-Tyne) remarked that the indicator-diagrams were not good ones.

Prof. HENRY LOUIS (Newcastle-upon-Tyne) remarked that the mechanical efficiency of the Lumpsey compound engine was 76 per cent., while those of the Park and Skelton engines, not compounded, were 78 and 79 per cent., and the net result of compounding the Lumpsey engine seemed to be a loss of efficiency of 2 or 3 per cent.; and he (Prof. Louis) asked the writer why he recommended compounding, when that was the result of his experience.

Mr. S. F. WALKER (Bath) remarked that, in his experience, it was extremely difficult to ascertain what those who were interested were paying for a horsepower. He was not aware whether they knew themselves, but at all events they never told others. At Lumpsey mine, 3·1 tons of stone were raised in each wind of 27 seconds; and that work cost 6·9 pounds of coal per actual horsepower-hour. The engine was compounded, the steam was condensed, and although the engine had not the Koepe endless winding-rope, all had been done that could be done with steam, and 6·9 pounds of coal were expended per actual horsepower-hour. In addition, there was the cost of generating the steam, apart from the coal used, the interest on the plant, the cost of water, etc.

Mr. M. WALTON BROWN (Newcastle-upon-Tyne) remarked that the total cost per annum of producing steam per indicated horsepower-hour, where coal was used as fuel, would vary from £10 upwards.

Mr. PHILIP KIRKUP (Birtley) suggested, with regard to Mr. Kirby's conclusion, that three-cylinder triple-expansion condensing engines would be economical, but should be limited to

the case of deep mines. At shallow mines, where stoppages were so frequent, it would be impracticable to use a triple-expansion engine.

Mr. James S. Dixon (Bothwell) remarked that Mr. Kirby stated in his paper that "little advantage was gained by using the condenser." Fig. 1 (Plate XII.) showed the condensing-plant at the Lumpsey mine condensing the steam from several engines, and the author seemed to hint a doubt as to whether that was a good method, as so little advantage was obtained from it. He asked whether there was any real reason why a central condensing-plant should not give a good vacuum on a winding-engine, simultaneously with that of other engines. Mr. Kirby seemed to doubt whether it could be done.

Mr. C. C. Leach (Newcastle-upon-Tyne) thought that it was easier for the engineman to work the engine when the condenser was off, and he was glad to leave it off. At all events, that was his (Mr. Leach's) experience.

The Chairman (Mr. H. C. Peake) moved a vote of thanks to Mr. Kirby for his paper.

Mr. P. Kirkup seconded the resolution, which was cordially adopted.

Mr. F. Hird's paper on "The Electric Driving of Winding-gears: Supplementary Note," was read as follows:—

THE ELECTRICAL DRIVING OF WINDING-GEARS: SUPPLEMENTARY NOTE.*

By F. HIRD.

At the general meeting held in London in July, 1903, the writer had the honour of reading a paper on the above subject, and drew the attention of the members to the developments in electrical winding-gear which were made possible by the then newly-developed Siemens-Ilgner system. It was, at that time, impossible to give any actual figures as to results, as no installation was then at work.

Fig. 1.—Siemens-Ilgner System: Winding-plant installed at Friedrichshall. Motor-generator viewed from Motor-end.

As actual tests are now available, and as the interest in this subject has certainly not decreased in the two years which have since elapsed, the writer now supplies the following results as a supplement to his original paper.

* *Trans. Inst. M. E.*, 1903, vol. xxv., page 592.

The plant on which the following tests were taken is installed at Friedrichshall, at the König-Wilhelm II. shaft, and consists of the following apparatus:—(1) A winding-gear, consisting of a double cylindrical drum-winder driven by one direct-coupled motor. (2) The starting apparatus consisting of a variable-voltage continuous-current generator driven by a three-phase motor of 2,000 volts. 50 periods, the two being coupled to a fly-wheel weighing 8·8 tons and having a diameter of 8 feet 3 inches.

FIG. 2.—SIEMENS-ILGNER SYSTEM: WINDING-PLANT INSTALLED AT FRIEDRICSHALL. SIDE VIEW OF MOTOR-GENERATOR.

The speed of this set is 600 revolutions per minute, at an absolute maximum, and falls to 15 per cent. below this speed when the greatest demand for power is made. The power delivered by the variable-voltage generator reaches a maximum of 305 horsepower, which occurs at the end of the acceleration-period. The power then falls to 215 horsepower, when the constant speed of the cage is attained, and continues to fall to 95 horsepower.

A separate small motor-generator gives the necessary exciting current for the winding-motor and for the motor-generator.

The shaft has a depth of 617 feet (188 metres), and the con-

tract specified that two full trucks, containing 1,543 pounds (700 kilogrammes) each, were to be raised at each lift, and that 55 lifts per hour must be made. The tests were taken to demonstrate that these conditions were fulfilled, and to determine the consumption of energy in so doing. The energy was measured at the terminals of the motor-generator, and includes all losses in the same, as well as all electrical and mechanical losses in the winding-gear and shaft. The energy for exciting the motor-generator and winding-motor was separately measured and added.

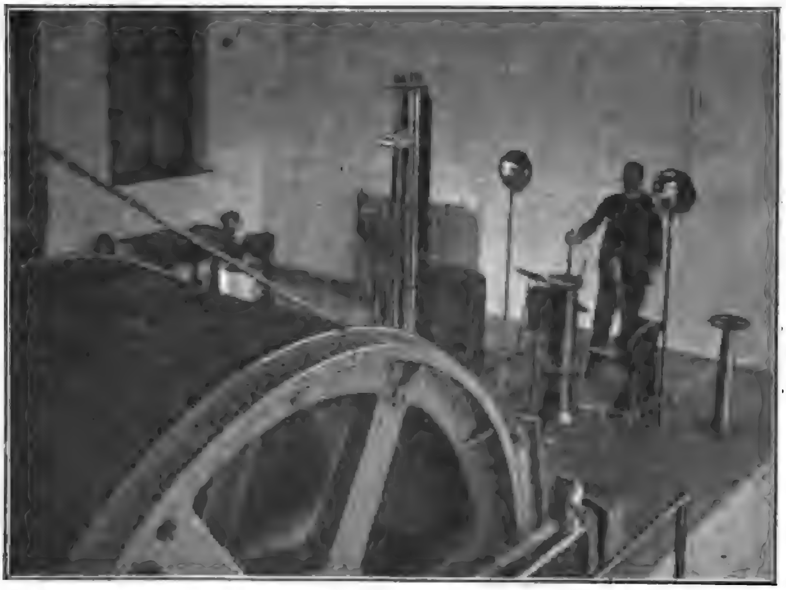

FIG. 3.—SIEMENS-ILGNER SYSTEM: WINDING-PLANT INSTALLED AT FRIEDRICSHALL. WINDING-ENGINE.

At the first test, 55 lifts per hour of two full trucks each were made, and the energy-consumption was found to be 1·55 kilowatt-hours per lift.

On a second test, 63 lifts per hour were attained, and the consumption of energy was the same as before: 1·55 kilowatt-hours per lift. During this test, a maximum speed of 23 feet (7 metres) per second was attained, and the time of one lift was 36 seconds.

The average load in the trucks was found to be 1,488 pounds (675 kilogrammes).

The net useful work in each lift (2 tubs × 675 kilogrammes × 188 metres) equals 253,800 kilogrammetres, or 1,836,000 foot-pounds, namely, 0·927 horsepower-hour equal to 0·69 kilowatt-hour. The electrical energy consumed was 1·55 kilowatt-hours, giving a total efficiency of (100 × 0·69 ÷ 1·55 or) 44·5 per cent.

The load on the generating plant was found to be fairly steady, and the flywheel of the motor-generator was apparently ample for its work, the speed-variation during working being no more than 7 per cent.

The ease of manipulation left nothing to be desired: any speed from dead slow to full speed being easily obtained, and steadily maintained.

Mr. H. W. Ravenshaw (Hanwell, London) wrote that he would like Mr. Hird to tabulate the losses in the motor-generator and the watt-hours per wind delivered to the winding-motor. He (Mr. Ravenshaw) considered that the total efficiency of 44·5 was not very good, and he suggested that an analysis of the various losses would be of great interest to the members; it would also be useful to have the actual kilowatt-time curves from the primary and secondary circuits.

Mr. W. C. Mountain (Newcastle-upon-Tyne) said that the question of electrical winding depended upon whether it would be economical to erect electric machinery. The members might be interested in the figures of a scheme which he had prepared a few days ago. It was proposed that 2,500 tons per day of 10 hours, or 250 tons per hour, should be wound from each of two shafts, or a total of 5,000 tons per day. The proposed speed of winding was 68 feet per second. Each winding-engine required a generating-plant of 1,500 kilowatts, driven by a compound engine supplied with steam at a pressure of 150 pounds per square inch. The motor-generator consisted of a motor of 2,000 horsepower, driving a dynamo of 3,000 kilowatts normal capacity, but capable of working up to 5,000 kilowatts; the weight of the flywheel was 100 tons, and it could be run up to 250 revolutions per minute. The winding-gear was to be

fitted with two motors of 1,500 horsepower each, or collectively of 3,000 horsepower, and capable of developing 5,000 horsepower when accelerated. The cost of each generating-plant, that is, the engine, dynamo, switch-boards, motor-generator, winding-gear and motors, was £21,000, or £42,000 for the two sets. The saving of coal was estimated at about £1,250 per year. A steam-plant, to do the same work with the highest class of engine, would cost under £6,000 per set, or £12,000 for the two sets, shewing a difference of £30,000 between the two schemes. Consequently, the saving of coal did not justify such an enhanced expenditure.

There were many cases where electricity could be economically adopted, where the power was obtained from coke-oven gases, or from cheap power-stations; but he felt that the field for electric winding-engines was a limited one, and when dealing with horsepowers exceeding 1,000 it was more economical to erect a high-class steam winding-engine than to adopt electricity for winding work. The plants that he saw in Germany were only lifting at the rate of about 30 feet per second, whereas at Wigan he had watched an engine winding at the rate of 120 feet per second.

Mr. C. C. Leach (Newcastle-upon-Tyne) said that he had two winding-engines: they were very old ones, but the coal-consumption was very little over 1 per cent. including everything; consequently there was but little room for saving by electric winding.

Mr. H. Jones (Bradford) remarked that, with the Siemens-Ilgner system, 1·55 kilowatt-hours were used per lift, and there were 55 to 63 lifts per hour. Taking 60 lifts per hour, 93 kilowatt-hours would be used or 930 kilowatt-hours for 10 hours per day. The cost, assuming that power could be bought at 0·8d. per unit, would be £3 2s. per day. The engine was capable of drawing 40½ tons per hour, at a cost of 1·85d. per ton. He presumed that the storage flywheel, running at a peripheral speed of 15,000 feet per minute, was built up.

Mr. Gerald H. J. Hooghwinkel (London) wrote that on account of the intermittent work and the more or less inefficient condensing arrangements, a triple-expansion winding-

engine was not to be recommended. A winding-engine might be compared to a steam-locomotive, only it was in a still worse condition on account of the frequent reversals, and the question of compounding, condensing and triple-expansion might be expected to give approximately the same results in a more pronounced degree.

An every-day steam-consumption of 35 pounds per useful horsepower-hour on the rope was not to be expected. The writer had collected a large number of steam-consumption figures of steam winding-engines in this country and abroad, eliminating the very old steam-eaters, and he had obtained an average of 100 pounds of steam used per useful horsepower-hour on the rope. This figure had been challenged by makers of steam winding-engines, who supplied much lower figures under ideal conditions, but not from actual every-day practice and as an average figure. Mining engineers, however, had as high as 200 pounds of steam in several cases. By very careful handling of a steam winding-engine, this figure might, in most cases, be reduced to 70 to 80 pounds, but this again was not an average.

The steam-consumption of electric winding-engines depended on the conditions of generation, and varied between 20 to 40 pounds of steam per useful horsepower-hour, as taken from every-day practice. Mr. Hird's figures for the König-Wilhelm colliery corresponded to about 30 pounds of steam per horsepower-hour.

Many electric winding-engines were now being worked, which compared with powerful steam-winders, although the speeds were generally somewhat lower. He was inclined to adopt a speed nearer to the high speeds used in steam-winders, which was required by the conditions of the efficient working of expensive shafts. German engineers were gradually increasing the speed of winding, and a compromise between the two extremes would prove the correct solution, so far as efficiency and moderate first cost were concerned, without going to the high speed of 120 feet per second.

The flywheel of the Siemens-Ilgner combination was invariably made of one steel casting, and it was often enclosed; and no accident had occurred in any case with which the writer had been connected.

The question of the speed and the size of the winding-plant,

raised by Mr. Mountain, was an interesting one and could not be discussed in a few words. However, there were no reasons why the electric winding-engine should be less economical for heavy outputs; and outputs of 250 tons per hour could easily be dealt with at a much lower cost than that quoted by Mr. Mountain. In such cases, everything depended on the number of winds and the time required for each wind. This time might be divided into the actual winding time and the time required for banking, starting and stopping; and, as a rule, these constituted the greater part of a complete wind.

By using three- or four-decked cages and other mechanical means, the banking operations might be effected in much less time, thus shortening the duration of a wind. On the other hand, the electric winding-engine by its quick, automatic and accurate handling gave a much higher average speed and a lower maximum-speed. Consequently, very high maximum-speeds were not required from electric winding-plant.

Mr. Mountain did not indicate the source from which the current would be supplied, and this of course governed the price of the complete plant. Was the current to be taken from a special separate power-station or from a power-station supplying power for the entire colliery; or was the current taken from the mains of a power-station which also generated current for, say, ten other electric winders, in this way equalizing the momentary demands on its engines?

In all three cases, his (Mr. Hooghwinkel's) figures would be considerably below £42,000 and nearer £30,000. On the other hand, the saving in fuel alone would be about £1,500, taking coal at 4s. a ton. The boilers did not appear to be included in the £12,000, which a condensing compound steam-winder was going to cost, and this would bring the figures of both types still nearer together. The boiler-and-engine equipment for a properly designed electric winding-plant need only be equal to the average demand on the engines, and this was about one-half of the maximum-demand.

There were other advantages, which, although not so easy to convert into money, were by no means less important. Among these might be enumerated, without going further into the matter, less wear-and-tear of machinery, therefore less maintenance and longer life, the same for the winding-ropes, less

working costs on account of less and cheaper labour, elasticity as regards raising the output, and safety on account of easier, steadier, and automatic handling. Electric driving was also better adapted to be used with a Koepe pulley, which was often preferred for various reasons, one being the prime cost.

A few examples (Table I.) of recently installed electric winding-plant for comparison with Mr. Mountain's figures would be found useful to refute the remark that electric winding was only being installed for such small outputs as the plant under review.

TABLE I.—ELECTRIC WINDERS.

Name of Mine.	Coal wound per Hour.	Depth of Shaft.	Speed per Second.	Description of Current.	Pressure of Current.	Number of Tubs in Cage.
	Tons.	Feet.	Feet.		Volts.	
Zollern II.	250	1,650	65	C	500	6
Mathias Stinnes ...	100	2,700	48	A	5,000	8
Wendel	175	3,000	60	A	3,000	8
Mansfeld	100	1,875	40	A	3,000	4
Preussen	100	2,400	52	A	2,000	4

NOTE.—A is alternating, and C continuous current.

The large winding-engine on the Ilgner system at the Zollern II. colliery, had been at work for about 1½ years. The engine was designed for winding 2,000 tons in 8 hours, or 250 tons per hour, from a depth of 1,650 feet, at a speed of 66 feet per second. It was therefore of about the same size as the example referred to by Mr. Mountain. At present, the output was less, as the colliery had not reached its full output, but about 2,100 tons were wound in 12 hours: over 1,500 tons being wound during the morning shift of 8 hours, or nearly 200 tons per hour. The Ilgner set was kept running the whole of the time (24 hours), so that the losses, of which so much had been made, were included in the steam-consumption figures (Table II.). The main purpose of the Ilgner set was to reduce the size of the generating-plant, and to ensure a constant load on the plant: this object had been attained. The various curves that had been taken showed a nearly constant consumption of 400 ampères at the Ilgner-motor terminals, while the winding-motor varied between *plus* 2,000 and *minus* 1,000 ampères. The generator at the Zollern colliery, without the Ilgner balancer, would have been required to produce 1,000 kilowatts on an average, while

now only 250 kilowatts were required by the winding-plant. The average for the period of 24 hours shewed a steam-consumption of 28·5 pounds per useful horsepower-hour at the pit-mouth.

TABLE II.—RESULTS OF A TEST FOR 24 HOURS, ON NOVEMBER 25TH, 1904, OF THE ELECTRIC WINDER AT ZOLLERN II. COLLIERY.

Period of Test.	Morning Shift 6 a.m to 2 p.m.	Miners' Shift 2 p.m. t 3 p m.	Afternoon Shift 3 ·.m. to 10 p m.	Night Shift 10 p m. to 6 a.m.	24 Hours.
Total units	9,076·33	715·82	7,506·75	4,770·70	22,069·60
Steam-consumption per unit .. pounds	17·00	18·00	16·80	18·60	......
Electric horsepower-hours at the pit-mouth ...	1,562·00	13·05	990·13	92·00	2,657·18
Steam-consumption per useful horsepower-hour at the pit-mouth ... ... pounds	23·50	117·00	26·50	111·50	28·50

The CHAIRMAN (Mr. H. C. Peake) moved a vote of thanks to Mr. F. Hird for his interesting paper.

Mr. S. F. WALKER seconded the resolution, which was cordially approved.

Prof. HOWARD ECKFELDT's paper on "The Education of Mining Engineers in the United States" was read as follows:—

THE EDUCATION OF MINING ENGINEERS IN THE UNITED STATES.

By HOWARD ECKFELDT, B.S., E.M.,
Professor of Mining Engineering, Lehigh University, South Bethlehem, Pa., U.S.A.

The education of mining engineers is a subject which will admit of treatment at great length, but, as time and space will not permit it in this case, the writer has attempted to give briefly in the following pages a general survey of the subject in question, and begs the indulgence of the members of the Institution, knowing that some errors may have crept in and that some of the statements made may not be exactly in accordance with their views.

There are in the United States about forty-five mining schools, which confer the degree of "Engineer of Mining" upon their graduates, and it is from the catalogues of the more important of these institutions that much of the data have been drawn for this paper.

The position which the mining engineer in the United States holds among his fellow engineers of to-day, is the result of a demand which has arisen within a comparatively recent period of years. It is the result of a demand for an engineer with that broadness of education and training which enables him to undertake readily the great variety of propositions which naturally present themselves to one of his profession. What is true of the mining engineer, so far as his education is concerned, is true of all engineering education in general, and it would not be out of place in this paper to glance at the past conditions of education and lead up to those of the present.

Forty, and even a less number of years ago, general public opinion was against engineering education; the technical graduate was looked upon as a being who was almost entirely useless to the industrial world, and at the best was little better than the average labourer; and if he maintained a polished appearance and had a good head on his shoulders, he was con-

sidered as well fitted to fill a clerical position. At all events, he was classed as one who had his mind full of ideas and theories which would not stand the test against the old "cut-and-dried" rules of years of practice. It is much to be regretted that, even in the present age of educational advancement, one occasionally meets a manager or superintendent who makes the boast that "No college men are to be found in my employ. I have no use for them." Happily this class is believed to be fast disappearing, and the usual clause added to an advertisement for technical help is—"College or university graduates preferred."

Engineering courses of study, 40 years ago, were more scientific than technical. It was acknowledged that the principles underlying the sciences were, to a more or less degree, of value in the construction of machines and structures, hence much stress was laid upon mathematics, chemistry and especially physics; while the arts of drawing and surveying were considered of great importance. The particular practice of an engineer of that day was considered as a part of his "stock-in-trade" and as a part of his capital; his mode of designing or constructing was more or less a secret of his own, and discussions upon engineering subjects were almost unheard of; and questions of economic importance regarding constructions of any kind were rarely brought to the attention of the student.

Such a state of affairs could not last for an indefinite time—the tide of progress which is characteristic of the country demanded something to keep pace with it, and the changes have been really marvellous. This pressure of the public, in the main, has brought about the proud position which engineering now holds,—new professions of equal dignity with the so-called "old" professions.

The scientific education of the older engineering courses recognized the fact that the principles of science were truths, the study of which were inspiring and edifying, in that they explained the laws of the universe—thus partaking of the old classical education; that the forces of nature must be thoroughly understood and controlled, in order to continue to advance the condition of mankind; that these forces could be studied by experiment alone; that by so doing the laws governing these forces would be developed and could be applied in the industrial and technical world; and that certain groups of laws more or

less closely related would find a more general application when applied to certain lines of work. Procedure along these lines has brought about the gradual development of the scientific institution into the high-grade engineering school of the present day.

The older engineering schools offered comparatively few courses of study, but with the growth of the system of technical education, the tendency has been towards an increased number of studies. This expansion was not spontaneous, but was due principally to the demand on the part of the public for specialization in the many branches of engineering. It has been found, in some cases, that such specialization tends towards a narrowness of field of view, and that the graduate fails to build up the broad foundation which should be gained from an engineering course, and upon which alone he may hope to build a successful career.

As the field of the mining engineer is naturally a very extensive one, a thorough education in all the fundamental principles of technology and a special training in many branches of all of the technical courses are necessary. It is believed that, in his case, the tendency toward specialization is very much less than in any other course, since of necessity the scope of studies must be a wide one; this enables the graduate not only to enter upon the field of mining, but also to take up work in the professions of chemistry, geology, metallurgy, electro-metallurgy, chemical, civil, electrical and mechanical engineering,—advantages not common to other courses.

Having noted some general features relative to engineering education, it may be well at this point to enter more into detail upon the subject in question.

The mineral resources of the United States, which are being exploited, and the vast areas of virgin ground that have yet to yield their treasures, insure for many years to come the needs of the services of competent mining engineers in developing and working them. With this need in view, nearly every one of our States now has its own "School of Mines," either as a separate institution or as a part of the State University; while scattered over the land, particularly in the east, are found the "pioneer" mining schools of the country, one of which forms a part of Lehigh University.

The length of the course of study in most of the mining schools is and has been, four years. There are, however, one or two institutions at which the five years' course still exists. Four years have been generally accepted as the standard length for all engineering courses throughout the country, but at present, there is in some localities a strong inclination towards reducing the number of years to three, and this is upheld by several of the prominent educators. With higher requirements for admission, this change may in the future be made possible, in which case a great part of the mid-year and summer vacations would have to be utilized for the practical work of the course. There appears to be no imminent probability of this change coming into effect.

There has been and still exists a strong tendency towards shortening the length of the college year; formerly about 42 weeks were deemed necessary to complete the work, while at present many schools complete the same in about 32 weeks. Many of the students take advantage of the long summer vacations, and secure positions at practical work along the lines of their chosen profession; while the teaching staff may utilize the same time in securing a fresh fund of knowledge from new developments in mining and its allied branches. Whether or not the individual is employed, it cannot be denied that too long a vacation is somewhat demoralizing, and renders it more difficult "to get into harness" promptly at the re-opening of college. Apart from the above, the fact that the college buildings and the equipment remain idle for so great a part of the year, cannot be considered as wise from an economic standpoint.

The system of continuous work for the whole year, which would enable the course to be completed in three years, has a few advocates, but happily they are few.

As it now exists, the development of the mining engineering school has been characterized by one element which is of vast importance in the after-life of the graduate, and that is, the training to do hard work with a thoroughness of study. The number of topics to be covered in a limited space of time and their bearing upon practical work and upon each other, require many hours per week of toil and diligent application. This earnestness of purpose and activity of mind is generally characteristic of the engineering student as compared with those of non-technical departments.

As the tendency toward broadness of education in all technical courses is ever on the advance, so the amount of work required to be done by each student tends to increase, but as the time in which such work can be done and the individual's capacity for the same are limited, there must be some compensating feature, and that is, to make the requirements for admission higher. On this account, some of the more elementary work formerly given in the first year is now done before the student enters college. This enables him to have secured a more comprehensive training, inasmuch as the advanced requirements tend towards increase of work in mathematics, the elementary sciences of chemistry and physics, and also in modern languages, etc. The effect in the end of this advance in entrance-requirements is to raise the average age of admission of the student. It is highly desirable that the candidate should have reached an age at which he realizes toward what line of work his natural abilities incline, and these, in general, are sufficiently developed only when he has reached a somewhat mature age. This realization is generally arrived at while he is pursuing the work in the elementary sciences required for entrance. Instances are too frequent of young and immature students entering some course of engineering because "some one else" takes it, and because it is a popular one, only to find that they have mistaken their calling. Changing from one course to another is demoralizing in the extreme. The older men in the class invariably do the most satisfactory work, and their chance of success upon graduation is correspondingly greater. Hence, whatever tends to raise the age of admission is worthy of encouragement. The present average age at which mining students enter college is about 18½ years.

Thus far, the writer has considered some of the general features of the mining engineer's education, and therefore he will now consider the scheme of studies and combinations of such that give the mining student the foundation for his general technical education, and later will deal with the studies which bear more directly upon his profession. Space will not admit of a detailed exposition of each of the studies, and a brief outline of the main line of work along each will be sufficient to give a good understanding of what it is aimed to accomplish.

Mathematics, with the "clean-cut" reasoning that pertains thereto, is without doubt the most important fundamental sub-

ject of all engineering studies. The training in logical reasoning and the ability to follow and grasp, step by step, develop the most important mental power of an engineer. On this account, it is taught with great thoroughness, and the combined courses in this subject generally extend over two years, or one-half of the entire college-course, the general limit being through the integral calculus.

The present tendency in this line is to do away, in a large degree, with the old method of instruction by the formal logic of the text-books, with their series of rules and abstract problems, and rather to impress the value of the subject upon the student by its application to the most practical problems in everyday engineering.

To the engineer, mathematics is the fulcrum of the lever, upon which the harnessed forces of nature acting as the power, are applied to effect the solution of the problem which confronts him.

If the student harbours the thought that mathematics serves only as mental training, his interest will flag and fail; but, on the other hand, if he can be made to realize what mathematics has done and is doing for the advancement of our welfare, he will have aroused in him an interest and zeal which will render all other work, however difficult, easy to overcome. There is one weakness occasionally cropping up, which demands a speedy remedy, and that is—the lack of adequate preparation in the first principles of mathematics. One frequently encounters the student who can differentiate and integrate with the utmost facility; while, if given a simple problem in multiplication and subtraction, he will be unable to give the correct result in a specified time. This means that common and preparatory schools should give more time and training to this important part of mathematics, while in our engineering schools the instruction that obtains the best results is the one that gives the greatest number of numerical problems by which to expound its teachings.

There is another failing, which happily is passing away, and that is, the tendency to work out results to the third or fourth decimal place, when the original data are in themselves only accurate as a whole number, or at most to the first decimal place. Mathematics implies that not only accuracy and correctness of reasoning should be sought, but that consistency should enter into the computation as well.

Mechanics, the science which treats of the laws of force and motion, is pre-eminently next to mathematics in importance to the engineer. Mechanics is an experimental science, the laws of which are based upon experiment and observation, and should be taught as such. However, on account of the mathematics involved in the deduction of its laws, the theoretical branch of the subject is frequently taught along with mathematics. In this way, the student very frequently gains the misconception that it is a part of mathematics; and, if he dislikes the one, he will generally dislike the other. The remedy is obvious—let theoretical and applied mechanics be taught together. The amount of time devoted to this subject is generally about a year, and the course frequently includes analytical mechanics.

It may be well, in this connection, to note the difficulties that constantly arise from the use of the old systems of weights and measures. In mechanics as well as in physics, the metric system has now come into almost universal use, and the future certainly has in store its adoption by the engineering world at large. The writer, during a period of four years' work in Mexico, had the opportunity both to see in use and apply the decimal system of weights and measures, and in his opinion its value of inter-convertibility from all standpoints cannot be over-estimated. The objection to its use by manufacturers and constructing engineers is clearly one of translation of units of calculation and of dimensions of designs now existing. Its general application must be a gradual one.

Some engineers have failed to realize the great importance of physics, and as a result, the instruction in this important subject has been somewhat neglected in the past. The recent magnificent advances in electrical research have brought this subject to a far more prominent position than it otherwise would occupy. Indeed, so great has been this advance, that the sciences of light, sound, heat and mechanics have taken somewhat a second place as compared with electricity and magnetism. The value of all branches of physics is now being more fully realized, and the future will see its steady advancement. The various branches of this subject now occupy the attention of the student during a year or a year-and-a-half of his college-course.

Naturally, the study of physics involves a considerable amount of laboratory-work and in this connection it may not be amiss

to make a note regarding the amount of time advantageously spent in such work in general, and in shop-practice. The value of experiments, and practical work in the laboratories, is in many cases the only means whereby principles and laws, which in themselves are but abstract ideas, are rendered real and of meaning to the student. This inspires him with the spirit of research. There exists a tendency, however, of carrying such work to a dangerous degree; when the student begins to do it mechanically, or does it simply with a view of completing the work required, the advantage gained by such work is, in a measure, lost. It is on this ground that the advocate and the non-advocate of shop-practice as a part of the engineering course meet in a clash.

The deciding point in favour of, or against such work is that which determines whether the student is to become a mere mechanic or whether he is to become an engineer. To the writer's mind the limit is reached when the student thoroughly understands the working of the apparatus or machine in question, and can successfully manipulate it. A continued exercise with the same gives, it is true, dexterity and proficiency, but unquestionably the time thus consumed can be more advantageously occupied in other directions.

The writer also strongly advocates the grading of work in all studies whenever possible, to suit the individual; in this way the student works up to his capacity, and the maximum amount of training is received by each. This practice is undoubtedly the one which is naturally followed by the individual in his after-work.

One of the most efficient weapons in the hand of the mining engineer is that furnished him by the courses which develop the ability to design and to construct. In order that the engineer should have the power to execute a design with all due detail and clearness of construction, he must have acquired neatness, accuracy and despatch in the art of drawing. Occasion frequently demands that he should make an intelligent sketch of some piece, without the necessity of making a finished drawing; to this end he must possess the ability to sketch off, freehand, the necessary part, and yet have it perfectly intelligible to the reader. Probably more so than in any other study "practice makes perfect" in this one. The courses in drawing and design begin

almost immediately after the student enters the school (and in some cases the elements of mechanical drawing may be required as an entrance-requirement) and are practically continuous throughout the whole four years.

These courses lead to the plans for the development of a mining property and the construction of the mining, dressing, washing and smelting-plant with all its appurtenances. Whether he be a prospector, superintendent, or otherwise, this faculty well developed makes him the forerunner of civilization.

How many cities are now grouped around the entrances to mines, where but a decade or two ago could be found only trackless forests or desert wastes!

It is in these courses that the instruction can be carried to great length without overdoing the matter; due care should be taken, however, that the exercises should not partake of the nature of the conveying of mere information with little scientific training.

The aim of the education of the mining engineer should be to give him a consciousness of his mental ability, certainty and surety in its application, with that degree of scientific accuracy necessary to meet desired results in an economic manner. He should therefore be given original problems to solve unassisted, and should not be permitted to follow, or copy in a mechanical manner, the practice of engineers of repute. Should he prove unequal to the task, a simpler form of problem may then be set, which will lead up to the desired end, after which he should be permitted to compare his work with a standard. In this manner he gains that confidence in his own ability which is essential to the engineer who so frequently has to solve many different problems at close intervals. The work in construction and design is generally taken up during the last year at college, after the student has become familiar with the underlying principles.

A course in specifications, estimates and contracts is included in the courses of construction. This gives the student that training which will enable him to order materials and enter into obligations in an intelligent manner; technical reports upon some engineering work in progress, or on work that has been completed, also form valuable additions to the training in construction and design.

Mechanics of materials (strength of materials) is that branch of applied mechanics which treats of the strength and elasticity of the common materials used in constructions. It is one of the foundations upon which successful design is based. The courses are now strengthened as never before by the introduction of testing machines used in commercial tests, and the student of to-day has therefore great advantages in being able to witness the manner in which deformations or failures may take place in the materials which the market affords. This work generally extends over from half to a whole year.

Although some engineering schools omit the study of the English language from their curriculum, on the ground that it is properly a subject to be taken before entering college, the writer is supported in his opinion by many educators that one of the first requirements of an engineer is his ability to express himself clearly in writing and speaking. This important elementary branch of our education, unfortunately often appears to suffer from the same evils as those noted previously under the head of elementary mathematics.

The same statement that holds with English holds true with modern languages (German, French, Spanish, etc.). The mining engineer frequently finds it absolutely essential in his work in the four corners of the globe, that he should be able to speak in some other than his native tongue. This is especially true in the case of the last-named language. While it is true that most of the technical work in foreign journals speedily find its translation into English, yet the accomplishment of being able to read a publication in a foreign country and to converse with the population and particularly with the labourer, is certainly not to be overlooked.

In most of our engineering colleges the subjects of English and modern languages are ones which are looked upon with little interest by the student. One way out of this difficulty may be to substitute for the reading of classic literature, the reading of standard engineering publications of the past and present in the different languages. Let the student realize the utilitarian basis of their value.

A knowledge of political economy is of great importance to the engineering profession, thus enabling the purchase of supplies and the marketing of products to be made under the most favourable conditions.

Many engineering schools have made it a practice to have distinguished members of the profession deliver lectures before the student-body from time to time upon some topic of general interest, and it is a source of great inspiration for a student to see and hear a man who has made his way upward by the sound application of the principles of science and technical training.

Prescribed exercises in the gymnasium form a healthful adjunct to the life at most of the engineering schools, thus securing that balance of mental and physical power so important for the well-being of the individual. Athletic teams, for the most part, receive much encouragement. Apart from the physical benefit derived, the moral training of self-control, when one team meets its rival, is of great value and cannot be under-estimated.

The mining engineer should be thoroughly conversant with all kinds and forms of machines used in converting the various forces of nature into power. For this reason he takes thorough courses of study in the subjects of boilers, steam-engines, thermodynamics, hydromechanics, dynamos and motors, etc. These subjects are supplemented in general by work in the engineering and electrical laboratories. In these courses, the mode of manipulation of instruments for indicating and measuring currents, pressures and powers is learned; and actual practice in the handling and controlling of machines, with their limitations and applications, gives him the necessary familiarity regarding the size and position of prime movers in a plant.

The recent advances in electrical science, already mentioned, have found a very extensive application in the field of the mining engineer. It is indeed a matter of interest and surprise to one who looks into the subject a little, especially if he be familiar with the history of general development during the past decade or so, to note the enormous growth in the use of electricity as a power-medium in mining. It has shown itself to be the most valuable and efficient medium, unrivalled in convenience of application, unequalled in economy of operation, and indispensable as a factor conducive to increased production at lowest cost. It is, therefore, highly desirable that the engineer should have the most thorough knowledge of the principles of electricity and be able to apply them in its generation, distribution and utilization for power-purposes.

Surveying in all its branches is another subject that is of great importance to the mining engineer. It is in this branch that field-work plays the most important part. After a thorough exposition of the methods used in ordinary land, topographic, mine and railroad surveying, practice in the field and mine enables the student to become thoroughly familiar with their practical applications, and maps are made; he is also enabled to master the adjustments of engineering instruments and investigate their systematic errors. A course in geodesy, or one in practical astronomy, is very frequently given in connection with the subject of surveying.

Inasmuch as the mining engineer is generally engaged in developing natural resources, it is well to lay stress upon the fact that the more at home he is with nature the greater will be his ability. This can be developed by increasing his powers of observation and by arousing a spirit of scientific investigation, which will greatly increase his chances of success. With this end in view, courses in botany and zoology have been introduced in some mining engineering schools, with satisfactory results.

The foregoing studies are those which make up the general foundation of the mining engineer's education. The writer will now deal with the studies which belong more or less exclusively to his curriculum, and will begin with the more purely scientific.

While chemistry and chemical analysis are not at all peculiar to the mining engineer, yet he would find himself very deficient if he did not possess thorough knowledge and ability along these lines. Under the head of chemistry are generally included instruction in qualitative and quantitative analysis, assaying and blow-piping, all being given almost entirely in the form of laboratory-work. From two to three years are frequently devoted to these subjects, and the graduate will have acquired a sufficient degree of skill as an analytical chemist and assayer to enable him to analyse, by wet, dry or blow-pipe methods, all of the common fuels, ores, fluxes and gases, as well as metallurgical products.

The studies of crystallography, mineralogy, petrology (both megascopic and microscopic) and of geology at once place the mining engineer in a field by himself. It is he alone who, having become familiar with the various minerals, their crystalline shapes and mineral aggregations, knows the forms and structures

of the earth's crust, with its fossil life, and analyses the various forces which operate upon them. Through the study of economic geology he learns the mode of formation of mineral-bearing zones and their relation to the surrounding deposits, and can with confidence indicate where or where not certain minerals are likely to be found. Practice in field-geology enables him to make accurate maps of outcrops and sections of the same.

Mining and metallurgy are often so intimately connected that the mining engineer finds it exceedingly desirable that he should possess a thorough knowledge of the latter subject, and with few exceptions both are included in the mining courses.

Metallurgy naturally divides itself into the following topics: —General metallurgy, the metallurgy of iron and steel, and the metallurgy of gold, silver, copper, lead, zinc, mercury, tin, aluminium, nickel, cobalt, arsenic and antimony. The first-mentioned topic treats of calorimetry, refractory materials, furnaces, natural and artificial fuels, chimneys, blast-engines, etc.; the other topics are self-explanatory. The courses in metallurgy generally extend over a year to a year-and-a-half, and embrace, besides instruction by the medium of text-books, lectures, inspection and laboratory-work, a series of problems involving the calculation of temperatures from calorimetric observations, volumes of air required for combustion of fuels, gases produced from various sources, the smelting charges of blast-furnaces, material balance-sheets of the Bessemer and open-hearth processes, etc. Metallurgy proper is supplemented by a course in electro-metallurgy, which discusses the practical applications of electricity to metallurgical processes and refining.

The subject of mining will next be considered. Natural subdivision and convenience in instruction demand this subject's treatment under the following general heads:—Exploration or prospecting, boring, shaft-sinking, tunnelling, development of deposits, methods of working or mining proper, haulage, hoisting, drainage, ventilation, lighting, accidents, ore-dressing and milling, and the mechanical preparation of coal. To these topics is generally added a special course in construction, bearing directly upon mining, and a course in the administration of mines and mine-accounts. The course in mining design has already been referred to, under the head of design and construction in general. Nearly all the leading mining schools of the

country have in connection with them, laboratories fitted up for the purpose of giving training and instruction in ore-dressing and milling and in metallurgical work. This is now deemed a very important phase of a mining course, and consequently receives much attention. However, what applies to the remarks under the head of laboratory-work and shop-practice should be well borne in mind in this connection, as laboratory-conditions of dressing, milling and smelting may differ widely from those of practice, and the student thus gains false or erroneous ideas regarding commercial operations.

Many institutions have regular summer schools in mining, during which the students are required to make a systematic study of operations in mining districts and report upon the same. In some cases, actual practice in drilling, blasting, timbering, stoping, etc., is given. A radical innovation along this line was introduced last summer by a number of the prominent mining schools combined. The scheme was to lease a small mine and have the students work the same under the supervision and instruction of the teaching staff from the mining departments of the schools. Whether or not the operation was entirely successful from a financial standpoint does not call for discussion here; at all events, the practical results obtained are believed to have been highly satisfactory.

The course in mining generally covers from one-and-a-half to two years of the college work, and is taught by recitations, supplemented in the main by lectures and visits of inspection. The main feature in the instruction in both metallurgy and mining is to keep up to date with current practice.

At the close of the college-course, the student presents a thesis, the subject of which may have been selected from any of the more important lines of study. The object of this thesis is to show his ability to apply the principles and rules of engineering in the investigation of some special feature or in the design of some special problem. Formerly theses were long drawn-out descriptions with much detail and great compilations of data; this is giving place to more original work and individual investigation on the part of the student; many of the theses are worthy of publication in the technical journals.

It is gratifying to note that at most of the engineering schools societies have been formed among the students, the purpose

being to present at their meetings for discussion, papers which set forth the varying practices that have come to the attention of the individual members. To the student, the exercise of preparing a subject and presenting it for discussion or criticism by his fellows, is one of great value. It gives him that confidence which is well calculated to make him self-reliant. Apart from the above, discussions of important scientific problems from the columns of the technical journals form one of the strong features of these societies.

After the completion of the prescribed course, the mining engineering student receives the degree of E.M. (Engineer of Mining). It is an interesting study to glance over the list of mining alumni and see the varied professions which some are following. For the most part they stick to their profession, but frequently a number are engaged in civil, mechanical and electrical engineering, others are engaged in the practice of law, in general contracting and manufacturing, or in general business pursuits. The fact is that an engineer who is thoroughly grounded in fundamental principles, and who has received the proper training in their applications, has about as much chance of success in one field of engineering as in another. It is generally conceded that the education of the mining engineer embraces the broadest scheme of studies that is included in any one course. It is not to be wondered if he can thus step into so many divergent lines of work. This is one of the fields into which the specialization that leads to narrowness of thought, and is much to be avoided, certainly cannot well enter.

The calling of the mining engineer is not only to win the treasures from the bosom of "Mother Earth" and present them to us in a condition for our use, but to influence those about him through those principles which are set forth by his firm reliance upon the laws of science and of truth; his mission is to advance unceasingly the welfare of his country and that of his fellow-man.

The writer has appended to this paper the programme and synopsis of studies which are required for the degree of Engineer of Mining at Lehigh University.

APPENDIX I.—SYNOPSIS OF STUDIES IN THE COURSE IN MINING ENGINEERING AT LEHIGH UNIVERSITY.

English—		
Rhetoric	32	
History of the English language	32	
American literature ...	16	
English literature	32	
Literary criticism	32	
Essays	32	
Public speaking	32	
		—208
Hygiene		32
Gymnasium		64
German or French		96
Spanish (optional)		64
Physics—		
Mechanics and heat ...	48	
Electricity and magnetism	64	
Light and sound	64	
		—176
Economics		32
Chemistry—		
General chemistry	64	
Qualitative analysis ..	48	
Stoichiometry	32	
Quantitative analysis ...	96	
Assaying	48	
Blowpipe analysis	16	
		—304
Drawing, construction and design—		
Freehand drawing	32	
Mechanical drawing ...	64	
Metallurgical construction	48	
Metallurgical design ...	32	
Mining design	64	
		—240
Mathematics—		
Algebra and trigonometry	80	
Analytical geometry ...	80	
Calculus	80	
		—240

Elementary mechanics ...		64
Strength of materials		64
Hydrostatics and hydraulics		48
Mechanics of machinery ...		32
Graphic statics		32
Boilers		16
Steam-engine		48
Engineering laboratory ...		32
Electro-technology		64
Electrical laboratory		16
Surveying—		
Land-surveying (Summer School, 4 weeks).		
Topographic surveying (Summer School, 4 weeks).		
Mine-surveying and railway-surveying (Summer School. 4 weeks)—12 weeks.		
Mineralogy—		
Crystallography	32	
Descriptive and determinative mineralogy	48	
Blowpipe analysis	16	
		— 96
Geology, biology, etc.—		
Petrology	48	
Dynamic geology	48	
Biology	48	
Historic geology	32	
Field-geology	32	
Economic geology	48	
		—256
Metallurgy		144
Electro-metallurgy		16
Mining—		
Mining engineering	96	
Mining	48	
Ore-dressing	48	
Mine-constructions	16	
Mine-administration ...	16	
		—224

With the exception of the time noted in the Summer Schools, the above figures represent periods which may consist of one hour of lecture or recitation, two hours of drawing or work at the blowpipe, or in the petrological laboratory, or three hours of field-work or other laboratory-practice.

APPENDIX II.—PROGRAMME OF STUDIES IN THE COURSE IN MINING ENGINEERING AT LEHIGH UNIVERSITY.

The terms are of equal length, and the numbers indicate the exercises per week.

FRESHMAN YEAR.—*First Term.*—Mechanics (4), chemistry (2), chemical laboratory (2), German or French (3), freehand drawing (2), mechanical drawing (3), hygiene (2), English (3) and gymnasium (2).

Second Term.—Algebra and trigonometry (5), physics (2), physical laboratory (1), qualitative analysis (3), stoichiometry (2), mechanical drawing (1), German or French (3), English (2), public speaking (1) and gymnasium (2).

Summer School in land-surveying (4 weeks).

Sophomore Year.—*First Term.*—Analytical geometry (5), physics (3), physical laboratory (1), crystallography (2), metallurgical construction (3), quantitative analysis (3), English (2) and public speaking (1).

Second Term.—Calculus (5), physics (3), physical laboratory (1), mineralogy (3), blowpipe analysis (1), quantitative analysis (3) and English (2).

Summer School in topographic surveying (4 weeks).

Junior Year.—*First Term.*—Ore-dressing (3), geology (3), boilers (1), petrology (2), blowpipe analysis (1), assaying (3), strength of materials (4), biology (3) and economics (1).

Second Term.—Geology (2), mining engineering (2), mining (3), petrology (1), metallurgy (5), hydraulics (3), steam-engine (3) and economics (1).

Summer School in mine-surveying and railway-surveying (4 weeks).

Senior Year.—*First Term.*—Mining engineering (4), mine-constructions (1), metallurgy (4), electro-technology (2), mechanics of machinery (2), graphic statics (2), engineering laboratory (1) and field-geology (2).

Second Term.—Mining design (4), metallurgical design (2), mine-administration (1), electro-metallurgy (1), electro-technology (2), electrical laboratory (1), economic geology (3), engineering laboratory (1) and thesis (3).

Spanish may be taken during the Senior Year as an extra subject.

The Chairman (Mr. J. S. Dixon) moved a vote of thanks to Prof. Eckfeldt for his interesting paper.

Mr. C. C. Leach seconded the resolution, which was cordially approved.

Prof. James Park's paper on "An Outline of Mining Education in New Zealand" was read as follows:--

AN OUTLINE OF MINING EDUCATION IN NEW ZEALAND.

By Professor JAMES PARK,
Director of the Otago University School of Mines, New Zealand.

The course of instruction outlined by Prof. R. A. S. Redmayne is a welcome contribution to the literature relating to technical mining education.* The interchange of ideas on this subject cannot be other than productive of good, especially to those engaged in the responsible work of training the rising generation of mining engineers. In original research and technological skill, the mining school should be not merely abreast, but a day ahead of the industry. The ideal is one not easy to live up to. The fresh applications of scientific invention imported into all departments of mining and metallurgy, the lack of adequate and up-to-date equipment, the restraining influence of threadbare traditions, and the lack of opportunity presented to the teaching staff have made it difficult for many of the older mining schools to keep pace with the requirements of the time. The department of mining in the University of Birmingham begins its career in favoured circumstances; with well-equipped laboratories, and a proper appreciation of the value of original research.

The course of study prescribed in a mining school, while in every case based on first principles, commonly reflects the dominant mining industry in the place or surrounding district. That so clearly defined by Prof. Redmayne is no exception to this rule, and it was doubtless formulated after careful consideration of the local conditions and requirements. For this reason, the writer will confine his remarks to a short description of the general scope and intention of mining education, as we find it in the colony of New Zealand.

In this colony, technical education in connection with mining

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 465.

is provided as follows:—(1) By schools of mines situated in the chief mining centres; and (2) by a University Mining School carried on as a faculty of Otago University, one of the affiliated colleges of the University of New Zealand.

The gold-field mining schools provide for the instruction of underground mine-managers, battery-managers and assayers; the University Mining School for the training of mining engineers, mining geologists, mine- and battery-managers, mine-surveyors, and metallurgical chemists.

There are six primary mining schools. Four are situated in the Auckland gold-fields, at Thames, Waihi, Karangahake and Coromandel; and two on the western coast of South Island, at Reefton and Westport. These schools are subsidized by the Government, and are managed by councils elected by the local subscribers. The classes, for the convenience of the students (chiefly miners and battery-workmen), are mostly conducted during the evening. There is no entrance-qualification and no obligation to attend the classes regularly, or even to sit for examination.

The schools are generally well-attended. They have exercised a marked influence in raising the general intelligence of the mining community. The instructors and lecturers are, with a few exceptions, graduates of the Otago University Mining School.

The New Zealand Mines Department, as an incentive to the brighter students to graduate in mining, offers annually four entrance-scholarships to the University Mining School, of the value of £50, tenable for three years and carrying free tuition.

The Otago University Mining School occupies a position in relation to mining almost identical with that of the mining academies of Germany. It grants associate-diplomas in mining, metallurgy and geology; and prepares students for the B.Sc. degrees in mining and metallurgy. All the subjects of instruction for the associate-diploma are taught up to the B.Sc. standard.

The associate-course nominally covers three years, but in fact never takes less than four. The entrance-qualification is the matriculation-examination of the New Zealand University, but it is provided by the regulations that intending non-matriculated students over the age of 21 years may be registered for the

associate-course, on passing a satisfactory examination in English, arithmetic, Euclid and algebra, up to the standard of the medical preliminary examination. Casual students are permitted to attend lectures without examination, on payment of the University-fees, but their class-work does not count for the associate or B.Sc. courses.

The session consists of two terms of three months each, with a recess of three weeks between the terms. The long summer-vacation of five months is occupied by students in practical mining, metallurgical, geological or engineering work.

The dominant mineral-industry in New Zealand and the Commonwealth of Australia is gold-mining; and as nine-tenths of our graduates engage in that pursuit, the course of study is drawn up so as to encourage specialization in that direction. The mining course hardly differs from that outlined by Prof. Redmayne and need not be described in detail. In all the associate-courses, the first two years are devoted to pure mathematics, applied mathematics, physics, mechanics, general geology, mineralogy, petrography and geometrical drawing. The third and fourth years are spent in advanced laboratory-work and lectures, field-practice in land, mine and engineering surveying, and mechanical drawing, with special reference to mining plant and appliances, etc.

The metallurgical course deals prominently with the mechanical recovery of gold from gravels by hydraulicking, elevating and dredging; the crushing, pulverizing and concentration of ores; the treatment of gold-ores and silver-ores by amalgamation, chlorination, cyaniding, etc.; and with the construction, erection and working of the machines, plant, and appliances used in these processes.

The associate-course in geology, after the preliminary work in mathematics, chemistry, physics, mechanics, etc., provides for a two years' course in general geology, petrography and surveying; and a one year's course in blowpipe analysis, mineralogy, palæontology, mining geology, photography, freehand and landscape drawing, and geological field-practice. The geological course, although an exacting one, has attracted the most brilliant of our undergraduates.

Colonial experience has shown that an exact knowledge of land, mine and engineering surveying is one of the most necessary and valuable qualifications of a mining graduate; and for this reason candidates for the associate-diploma in each division of the mining school are required to take a two years' course in surveying.

No compass-surveys of any kind are recognized by the New Zealand Land Survey Department, or by the Law Courts; consequently, all land- and mine-surveys are made with the theodolite on the true meridian, and co-ordinated with a trigonometrical point.

Each student at the end of his second course in surveying, must produce plans of land actually surveyed and drawn by himself completely, and in a workmanlike manner, in accordance with the rules and regulations* of the General Survey Department of New Zealand, as under†:—(1) Of a base-line at least 1 mile in length. (2) Of at least one triangle as observed in minor triangulation, with topography, bearings, distances, summation, reductions on latitude and departure, etc. (3) Of a property at least 20 acres in extent, showing roads, fences, streams, etc., connected to a trigonometrical point, with boundary and intersecting roads reduced on true meridian, and drawn to a scale not less than 4 chains to the inch. The plan must be accompanied with tabulation of co-ordinates, and sheets showing the calculations of area, co-ordinates, etc. This plan must show a traverse of underground workings connected with the surface-boundaries; but, in cases where mine-workings are not accessible, the director may grant permission to the student to furnish a traverse of underground workings on a separate plan. (4) Of a section across a part of the land-area specified in (3), not less than 20 chains in length, showing the surface-profile of the ground as determined with level and staff. Pegs must be placed at the end of each chain, and a cross-section taken of the ground at each chain-peg.

Each student in his second year, in addition to the weekly field-work, is required to check the meridian of a survey-traverse by an observation to a star, and determine latitude and time by observations to a star or the sun.

* The maximum linear error allowed is 4 links in the mile, and angular error, 1 minute of arc.

† *Calendar of the University of Otago*, 1905, pages 116-117.

A student's standing in the final examination is determined as follows:—(1) On a written examination-paper on land-surveying. (2) On a written examination-paper on mine and engineering surveying. (3) On a written examination-paper on geodetic surveying. (4) On general proficiency in field-work during the session, and adjustments of theodolite and level. (5) On plans submitted for examination. And (6) on the accuracy and neatness of field-book, calculation-book and lecture-notes. Each candidate is also required to pass oral and practical examinations in the adjustments of the level and theodolite, both plain and transit.

A geodesic station, the latitude and longitude of which have been determined, has been established in a commanding position in the University grounds, for the use of students.

Students who have passed the class-examinations, in all the branches of study prescribed for any division, are entitled, without further examination, to the diploma of that division, subject to the following requirements:—*

I. Mining Division.—Students in this division are required:—

(a) To produce satisfactory evidence that they have spent at least 12 months in practical mining work—partly in coal- and partly in metal-mines; and of this period of 12 months, at least 9 months shall be spent in underground mining work, and not less than 3 and not more than 6 months in a coal-mine.

(b) To produce a lucid and concise thesis on the principles and practice of mining as carried on in some important mining district, giving prominence to the points hereafter mentioned:—(1) Physical features of the district. (2) General geological structure, with special reference to the lithological character, arrangement, and relationships of the mineral-bearing formations. (3) Description of mineral seams, veins or ore-bodies, with a discussion of their structure, pay-chutes, accessory minerals, and probable genesis. (4) Methods of mining, timbering, underground haulage and hoisting, with description of machinery and appliances. (5) Mining legislation relating to titles, rents, royalties, labour-obligations, etc. (6) Discussion of

* *Op. cit.*, pages 101-102.

climatic conditions, rainfall, waterpower, etc. (7) Prevailing sickness among miners, such as miners' phthisis and ankylostomiasis. (8) Schedules of mining costs, etc.

The thesis must be accompanied by complete working-plans of (*a*) ore or coal-bins; (*b*) headgear or poppet-heads; and (*c*) shaft-timbering.

II. Metallurgical Division.—Students in this division are required to produce:—

(*a*) Satisfactory evidence that they have spent at least 12 months in practical work, in ore-dressing and metallurgical operations.

(*b*) A thesis on some metallurgical process, as carried out in some approved mining district, special attention being given to such points as the following:—(1) The chemical and mineralogical composition of the ore. (2) A discussion on the chemistry of the detailed processes in use. (3) Detailed description of the plant and metallurgical operations, with working drawings; also working costs, etc.

Or (*c*) a complete set of drawings and specifications for the construction and erection of an ore-dressing and metallurgical plant for the treatment of some approved ore, the chemical and mineralogical composition of which has been determined. All drawings must be made to scale, and all necessary details, and quantities taken out.

III. Geological Division.—Students in this division are required:—

(*a*) To produce satisfactory evidence that they have spent at least 6 months in the practice of geological surveying in the field.

(*b*) To produce a thesis on the geology of some approved area, preferably a mining district, prominence being given to the following points:—(1) Description of the surface-features, with a general sketch of their development. (2) Formation and nature of the soil. (3) Detailed description of the minerals and rocks occurring in the area. (4) Discussion of the stratigraphical geology, including the identification of characteristic fossils. (5) Coloured map and sections drawn to scale, illustrating the geological structure of the district.

IV. SURVEYING DIVISION.—A certificate as a land- and mine-surveyor is issued to students in this division, who produce satisfactory evidence that they have spent at least 6 months in the practice of mine- and land-surveying, with a qualified surveyor.

Students in all divisions are required to produce certificates testifying that they have attended a course of instruction in ambulance-work.

This combination of theory and practice has been attended with the happiest results. Old graduates of the Otago University School of Mines are to be found occupying responsible positions as mining engineers, metallurgists, geologists, and teachers in Australasia, Africa, Asia and America.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Prof. Park for his interesting paper.

Mr. A. R. SAWYER seconded the resolution, which was cordially approved.

Mr. THOMAS ADAMSON's paper on "Goaf-blasts in Mines in the Giridih Coal-field, Bengal, India" was read as follows:—

GOAF-BLASTS IN MINES IN THE GIRIDIH COAL-FIELD, BENGAL, INDIA.

By THOMAS ADAMSON.

Goaf-blasts, caused by falls of roof, are more frequent in Indian mines than is the case in British mines, on account of the nature of the hard sandstone roof, which allows of large areas of coal being worked before a fall of roof takes place.

The nature of the roof in the mines of the Giridih coal-field has been described by Mr. R. R. Simpson.* Previous references to air-blasts have been made by Dr. W. Saise, in his paper on the Giridih (Kurhurbaree) Coal-field.† Dr. W. F. Smeeth refers to air-blasts in Indian gold-mines, in his report as Chief Inspector of Mysore for 1901-1902. The writer too has written upon the subject‡, as also Mr. T. H. Ward|| and Mr. J. Grundy, H.M. Inspector of Mines in India.§

The old system, and the one extensively followed now in some districts in working Indian mines, is to commence from the shaft, or from the adit, where the coal crops out, and drive headings and stentons, forming pillars, 20 feet to 100 feet square, until the whole of a district is cut into pillars. The pillars are then removed, commencing from the boundary and working back towards the shaft.

As a rule, several pillars are removed before a fall of roof takes place, with the result that heavy air-blasts are caused by the collapse of large areas of roof in the goaves. Sometimes, the roof breaks down in the area only where the pillars have been removed; at other times, the roof being of so strong a nature, it does not fall, but its weight causes crush on the pillars on all sides of the goaf, with the result that pillars are crushed out and lost.

* *Trans. Inst M. E.*, 1903, vol. xxv., page 192.

† *Records of the Geological Survey of India*, 1894, vol. xxvii., page 96.

‡ *Trans. Inst. M. E.*, 1903, vol. xxv., page 12.

|| *Ibid.*, page 193. § *Ibid.*, page 401.

Almost on every occasion that the roof breaks down a heavy blast of air is produced.

On one occasion, in 1885, where some pillars had been removed in a seam, 7½ feet thick, and the timber on the goaf-edge was being drawn off, the roof began weighting. Some of the workpeople were sent out of the mine, which was a shallow one, and the only roads into the mine were adits. Three of the men, amongst those sent out of the mine, sat down at the entrance to one of the inclines, in a cutting 8 or 10 feet deep. Whilst they were sitting there, the goaf collapsed, and the rush of air through the narrow cutting blew them a distance of 100 feet, killing all of them. The coal-cutting contractor, his *sirdar* (foreman), and several coal-hewers were in the mine when this happened: they were standing near the goaf-edge, where there were numerous galleries and small pillars. About 60 per cent. of coal had been worked out, so there was a large air-space. They were not affected by the blast; and they were surprised and shocked when they got out of the incline, and discovered the dead bodies of the victims. The whole of the volume of air, displaced by the goaf-fall, had to escape by the narrow inclined roads (adits) and must have been travelling at a great velocity to carry the men such a distance.

On another occasion, about 10 years ago, the pillars were being removed in another shallow mine, which had two inclined roads into it. One day, the roof commenced weighting and was crushing the knobs (*chowkidars*) that had been left to give indication of roof-weight. The workpeople were withdrawn from the mine at once, and the entrances to the mine were fenced off. A few days afterwards, the roof fell in, and the air-blast blew a tub weighing 4 cwts. (which had been left standing in front of one of the adits), a distance of about 200 feet down the hill-side.

On another occasion, about 9 years ago, a creep took place in a neighbouring colliery. A large number of pillars had been removed, and a weight came on the remaining pillars. The miners were withdrawn, and shortly afterwards the mine collapsed, and the air-blast blew the cages out of the shaft into the head-gear, smashing the latter.

Serampore Colliery.—In December, 1903, a goaf-fall took place in the Central pits of the East Indian Railway Company's

Serampore colliery (Fig. 1, Plate XIV.). The goaf, X, was about 400 feet in length by 300 feet in width. The whole of the seam, 23 feet thick, had been worked, excepting the *chowkidars* (tell-tales) 8 feet to 10 feet square, and 40 feet from centre to centre, which were left to give indication of roof-weight.

At 4·30 a.m. on December 3rd, 1903, while men were working on the goaf-edge, coal commenced to roll off the sides of the tell-tales. The deputy-overman (a native) at once withdrew his men, and took them back a distance of from 1,000 to 1,200 feet from the goaf, into man-holes (refuge-holes) and into the stables, and caused them to lie down, to avoid being blown down by the blast. The roof fell at 5·30 a.m., and the force of the blast blew out timber on the goaf-edge, and the stoppings, A, B, C, D, E, K, L, Q and R, and a ventilation-door at J. A carpenter at M and a coal-cutter at N, who had disobeyed the orders of the deputy-overman to lie down, and remained sitting, were knocked over by the blast, and were slightly injured. No one else received any injury. All the lights in the mine were extinguished.

All the openings to the goaf were closed by the fallen roof, and the pillars on the goaf-edge were only slightly crushed. Coal weighing 97,722 tons was got from this area, and 4,500 tons were left in the tell-tales, so that nearly 95½ per cent. of the total quantity of coal was got in this area.

Kurhurbaree Colliery.—One of the largest goaf-collapses that have taken place in the writer's experience is that which occurred in the Joktiabad mine of the East Indian Railway Company, on February 9th, 1905. This mine and the Central pits are worked on the panel system, which the writer has already fully described.*

A full section of the seam and of the overlying strata is detailed in Table I.

The goaf, E, was 700 feet in length by 300 feet in width (Fig. 2, Plate XIV.), and all the coal in this area had been got except 65 *chowkidars*† (tell-tales) 8 feet by 8 feet, spaced 40 feet apart, left as indicators of roof-weight.

* "Working a Thick Coal-seam in Bengal, India," *Trans. Inst. M. E.*, 1902, vol. xxv., page 10.

† *Chowkidar* or *chaukidar* is the Hindustani name for a watchman.

The first indication of roof-weighting was on January 26th, 1905, and lasted on and off for about an hour; it then went quiet, and remained quiet until 8 a.m. on February 9th, 1905, when it again began to be uneasy, and coal was being crushed off the tell-tales. The overman at once withdrew all his men from the south side of the mine, but kept the north and west sides of the mine at work.

TABLE I.—SECTION OF STRATA AT THE JOKTIABAD PITS, KURHURBAREE COLLIERY, OF THE EAST INDIAN RAILWAY COMPANY.

No.	Description of Strata	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In	Depth from Surface. Ft.	In.
1	Brickwork	17	9	17	9	16	Sandstone, dark	4	0	265	9
2	Sandstone	51	0	68	9	17	Sandstone	105	6	371	3
3	COAL	0	4	69	1	18	COAL	1	0	372	3
4	Sandstone	11	8	80	9	19	Sandstone	20	0	392	3
5	COAL	1	6	82	3	20	COAL	0	9	393	0
6	Sandstone	66	6	148	9	21	Sandstone	1	6	394	6
7	COAL	0	4	149	1	22	COAL	1	0	395	6
8	Sandstone	7	6	156	7	23	Sandstone	41	9	437	3
9	COAL	1	6	158	1		*Working Coal-seam—*				
10	Sandstone	8	0	166	1		Ft. In.				
11	COAL	0	6	166	7	24	COAL ... 5 0				
12	Sandstone	6	8	173	3	25	Sandstone 2 0				
13	COAL	1	9	175	0	26	COAL ... 9 0				
14	Sandstone	85	9	260	9		——	16	0	453	3
15	Shale	1	0	261	9	27	Sandstone	20	0	473	3

At 10 p.m. on the same day, the sirdar who was told off to watch and listen to this roof, heard main-roof bumps. He at once reported the same to the deputy-overman (a native) in charge of the shift, who stopped the rest of the mine, and sent the workpeople (a few men working in the night-shift) out of the mine. The deputy-overman and his sirdars remained in the mine, away from where the blast was likely to affect them, and at 12 midnight, the goaf collapsed, causing two heavy air-blasts. The first blast, and the heaviest, blew out four stoppings, S, S, S and S, and the ventilation-doors, A, B, C and D (Fig. 2, Plate XIV.). One of the doors was smashed to matchwood. Two loaded tubs and eight empty tubs were blown over, and one steel tub was knocked out of shape. These tubs were all lying between the doors B and C.

A few of the lights, but not all, carried by the deputy-overman and his party were extinguished; they stated that the wind rushed by them, when sitting, and did them no harm.

The horses which were stabled on the same side of the mine as that where the fall took place, were none the worse, except that they were covered with coal-dust.

The extent of the fall is shown by the cross-hatching on the plan (Fig. 2, Plate XIV.). All the openings leading into the goaf are closed with fallen roof, so that there will be no more anxiety in reference to blasts from it. It is not known what thickness of roof fell, but it must be of considerable thickness, as at times the sound of falling roof is heard.

There has been no subsidence of the surface from this fall, or from that at the Central pits. The pillars, surrounding this goaf, shew no signs of crushing, neither is the timber at all fast on the edge of the goaf. Coal weighing 106,738 tons was won, 2,150 tons were lost in this area, and 98 per cent. of the whole quantity of coal has been got.

This fall has relieved the management of no small amount of anxiety, especially since the first indication of weight was given on January 26th, 1905, as it is the largest fall with so great a cover (430 feet) that has taken place in Indian mines.

The listening to the goaf took place every 3 hours from January 26th, 1905, to the date of collapse.

At first some difficulty was experienced in getting silence when the *chowkidars* commenced "talking" (crushed coal falling off them). The overman or sirdar, in charge, had to shout at the top of his voice for some considerable time. As the men have got accustomed to the work, and to the necessity of acting promptly on the first indication of weight, little or no difficulty is now experienced. In large goaves, where work is going on in several places, at some distance apart, gongs are provided (made out of pieces of permanent-way steel rails). These are struck when silence is required, and act like magic in securing the desired result.

The greatest care, skill and discipline are required when working on the edge of large goaves like the last two described; and Dr. W. Saise, the superintendent of these collieries, has spent some years in perfecting the system of control of these operations.

Overmen who have had considerable experience in the working of the Thick coal-seam in South Staffordshire are preferred for this work as supervisors, and natives who have risen from coal-cutters act as their deputies. A new overman from Great Britain is sent with one that has had some experience under the peculiar

conditions met with in Indian mining, for at least 12 months, before he is allowed to take responsible charge; and the trainer, a senior overman, has to certify that the new man is able and can be trusted to take charge, and be left alone to carry on the work. The new man has also to pass a Government examination in the language of the miner, so that he can give his orders promptly and intelligently.

Considerable skill and judgment on the part of the overman are necessary when a goaf is on weight. Some men are inclined to stop the mine on the first indication of weight, and thus lose a large amount of coal-raisings by stopping the mine unnecessarily. A more experienced overman, who knows the nature of the roof and the behaviour of the *chowkidars* under weight, can tell to a day or so and sometimes to a few hours when the roof will fall. After the first fall of roof in a goaf, the rest breaks down more readily and in smaller areas.

It is the rule to stop all work near to a goaf which is weighting.

Mr. Lawrence Holland (Hamstead colliery) wrote that the conditions under which thick coal was worked in the Giridih coal-field of Bengal were certainly much more favourable than the conditions met with in working the Thick coal-seam of South Staffordshire. The coal did not appear to be liable to spontaneous combustion, as the plans (Figs. 1 and 2, plate XIV.) showed a considerable number of roads, which must stand for some time before being put into work. The sandstone-roof would greatly facilitate the working of the thick coal, by allowing large areas of coal to be removed before a fall of roof occurred, so that all the coal and slack could be loaded from the openings free from rock. At the same time, it prevented what was probably the most serious trouble in working the Thick coal-seam of South Staffordshire, that was, the constant occurrence of fire in openings, caused by the roof breaking down before the top coal was wholly removed, and burying a portion of it, which became ignited sooner or later.

A very large percentage of the seam appeared to be worked by the system adopted, but he suggested that it would be better to leave the remaining coal in large pillars, instead of a number

of small knobs or *chowkidars*, and to build great packs of stone between the pillars. Taking into consideration the cheapness of labour, one would think it advisable to adopt some such means as these to prevent the sudden collapse of 4 or 5 acres of roof, for if goaf-blasts were not dangerous, they were certainly destructive, if cages and headgear had been smashed, and stoppings and ventilation-doors blown out, to say nothing of the hindrance to the working of the mine, and risk of damage to the fan. It would be interesting to know the effect produced on an area of coal lying between two large areas of fallen goaf, as for instance the area between X and Z (Fig. 1, Plate XIV.). When it was worked, one would expect that a crushing weight would be produced by so strong a roof when the side-supports were removed.

Mr. Joseph Dickinson (Pendleton) wrote that most persons who had been much engaged in coal-mines had felt rushes of wind caused by falls of roof, but such blasts as Mr. Adamson described in his paper were uncommon. He was astonished to find that such destructive occurrences should be accepted as a matter of course. It was a serious thing to have tubs blown about, doors and stoppings blown out, and men killed. But amidst such wreckage it was pleasing to find that practical ingenuity had found some precautions—"the men have got accustomed to the work"; slender pillars, about 4 per cent. of the whole, are left as "tell-tales," the crushing of which gives warning of what is coming; the overman-in-charge shouts "at the top of his voice for some considerable time"; "where work is going on in several places, at some distance apart, gongs are provided"; and the miners are either ordered out of the mine, or into some roomy part, and made to lie down in order that the rush of wind might pass over them.

It reminded one of the precautions deemed sufficient in former times, when the singeing of men by explosions of fire-damp used to be thought by some as the best qualifications for a fireman; and when only firemen were allowed a safety-lamp, lest it should bring a bad name to the colliery. Experienced men could then go with an open light, judging by the cap, to within a few feet or so of explosive gas, but occasionally they were caught at last; and when roof was falling they would gently nip out the light lest fire-damp, as often happened, should

come off with the fall. The knowledge of these and such like practical devices was now very much less requisite, with the greatly improved ventilation and the use of safety-lamps, so much so that one had now seldom on feeling the suck to lie down on the floor or in the gutter, if there were one, until the rush overhead had passed by, and then, if unburned and able to do so, make for the shaft.

Seriously, however, one could not help thinking that the destructive rushes of wind described by Mr. Adamson should be dealt with by more reliable (automatic) means than the "tell-tale" pillars, the overman's shout and the gong. If falls were to be accepted as a matter of course, the extent should be moderated by support of the roof, even if material for the purpose had to be brought into the mine.

Mr. William Smith (Ayr) wrote that, at Houldsworth colliery, the whole of the coal had been removed from a space, 132 feet wide, 450 feet long and 10 feet high, and the 70 feet of overlying rock had not yet fallen. It had settled down about 2 feet, and in doing so, pieces of sandstone had broken off, about 2 feet thick and 8 or 9 feet long. It was now over two years since coal-working was commenced in this section and still the roof as a whole had shewn no sign of collapsing. Meantime, he was unable to say whether much or little warning would be given before the roof fell, or whether it would fall partially or altogether.

Mr. Fred G. Meacham (Dudley) wrote that the blast at Kurhurbaree colliery was most remarkable as taking place in a thick coal-seam, and it was interesting to find that so large an area could be worked out without leaving more than 5 per cent. of the coal as pillars, and these evidently only left as tell-tales, to guard against goaf-blasts. In the Thick coal-seam of South Staffordshire (24 to 30 feet in thickness) the roof consisted of soft carbonaceous matter, immediately upon the top of the coal-seam, and of soft grey clays and weak rocks for the next 40 to 50 feet, consequently, very few openings would stand more than 30 feet wide and the pillars must be made 24 to 30 feet square. The floor and the measures underneath the coal-seam, consisted of soft fire-clays, so that "creep" was very great, and it was rare indeed that any one working exceeded 1½ to 2 acres

in extent. These conditions precluded the occurrence of goaf-blasts upon so large a scale as those described by Mr. Adamson; but there was (and it was much more frequent when the shallower Thick coal-mines were being worked) the blast from falls of coal, which often extinguished all the lights unless protected. These falls were brought about by the fact that the upper layers of the coal were cut off from the solid and left hanging, supported by spurns and timber; when these were removed an area of 3,600 to 4,500 square feet of hanging coal fell and then the blast took place.

In the cases described by Mr. Adamson, he (Mr. Meachem) found that the areas at the Serampore colliery were ½, 1¼ and 1½ acres, while at the Kurhurbaree colliery the area was about 4½ acres; and it spoke well for the care and discipline that must prevail at these collieries, that such an occurrence could take place with so little loss of life. It would be interesting to watch the development of Indian coal-mines at greater depths: if the conditions of roof and floor remained the same, then goaf-blasts would have to be dealt with under worse conditions, and no doubt they will be dealt with as successfully as they were now; but, if the roof and floor became weaker, then falls would take place in much smaller areas and would not be so much noticed as at present.

Mr. James Ashworth (Chaddesden, Derby) wrote that he had been very much interested in Mr. Adamson's paper, particularly as he had given a good deal of attention to the subject ever since he had had an uncomfortable experience on the inbye-side of a large goaf, which had a rock-roof; and he afterwards came to the conclusion that the pressure-effect on the air from a fall might be very serious in a mine where fire-damp and coal-dust were always present. The first heavy fall to attract his attention occurred on July 18th, 1895, in the workings of the Broken Hill mine, South Australia. Such a high velocity and pressure of air were created that 9 men were killed in one of the levels.* In this article, he (Mr. Ashworth) suggested that more serious effects were demonstrated in coal-mine explosions, such as Llanerch, Timsbury, Albion, etc.

* "Some Effects produced by the Sudden Compression of the Ventilating Air-current in Mines," *The Colliery Guardian*, 1895, vol. lxx., page 974.

On May 27th, 1901, a mysterious explosion occurred at the Talk-o'-th-Hill colliery, by which 4 men and 27 horses were killed; and as none of the men killed were anywhere near the place where the explosion was found to have originated, it was attributed to a gob-fire. After the enquiry was closed and the workings were re-opened, no gob-fire was found, and none was known to exist in the mine before the explosion. He (Mr. Ashworth) contributed an article on the subject,* to show that the explosion might have been, and probably was, caused through the ignition of a mixture of air, fire-damp and coal-dust, by the percussive-pressure effect of a fall of rock-roof in the goaf. This suggested cause was considered by Mr. A. M. Henshaw, the general manager of the mine, and by Messrs. W. N. Atkinson and H. R. Makepeace, H.M. inspectors of mines, to be something impossible.

The discussion subsequently remained dormant, until the enquiry into the cause of the explosion at the Mount Kembla colliery, in New South Wales, when Dr. J. R. M. Robertson, the consulting engineer of the colliery, and his fellow experts, who had read the paper on the cause of the Talk-o'-th-Hill colliery explosion, found that there was no other way of accounting for the explosion than by the heat-effects of the huge and sudden pressure caused by a large fall of roof. The fall of roof was acknowledged by every witness, but only the coal-owner's witnesses showed that the pressure and velocity of air were, without any addition of fire-damp, sufficient to cause the whole of the damage to the mine, and the burning and other effects. In fact, Dr. Robertson said he was convinced that there was no actual flame, and that all the burning effects were caused by the heat of the suddenly-compressed air. The extraordinary part of this disaster was that there was practically no fire-damp in the mine, and that the whole mine was worked with open lights. One of the inspectors of mines had, only a few minutes previous to the explosion, passed the place where the fall took place, and had any gas been coming off he could not have failed to find it. No gas was found in the goaf, either before or after the disaster. The main haulage-road was wet, and the advocates of the value of watering should note that the explosion, whether it were a

* "Notes on the Talk-o'-th'-Hill Explosion," *The Colliery Guardian*, 1902, vol. lxxxiii., page 389.

coal-dust explosion, or only the effect of air heated by high and sudden compression, was not induced to turn either to the right-hand or the left into the drier roads; but a large volume of carbon monoxide was produced, and was the cause of death of most of those who lost their lives. The inspector of mines was rescued alive, but the writer understood that he had never been fit for duty since.

The latest accident from an air-blast was probably that at the Llanhilleth colliery, South Wales, in March, 1905. Seven men were chatting together in the main roadway, when a fall of roof took place above the timbering, without displacing it, forcing out the air and throwing them so violently along the roadway that 5 were rendered unconscious and 2 had serious bone-fractures.

These accidents were of themselves sufficient to prove that heavy falls of roof might be the cause of very disastrous occurrences in collieries, without in some cases showing any distinctive sign of their influence on the initiation of an explosion. The percussive effect, as shown by the Mount Kembla disaster, might be communicated to points at long distances apart, and under such conditions the air appeared to act as a solid rather than as a highly compressible gas. Another proof of the highly compressed state of the air under these conditions, as well as in colliery explosions resulting from other causes, was that a very large percentage of the deaths were due primarily to shock or concussion of the brain; and if the men were not actually killed by this effect, a small percentage of carbon monoxide was sufficient to make their deaths almost a certainty. The effect of air-percussion was clearly demonstrated in the case of the Universal colliery explosion, where appearances indicated that every separate ventilation-district was affected simultaneously, and points as widely apart as possible were suggested as the places of ignition.

Mr. Fred C. Keighley (Uniontown, Pennsylvania, U.S.A.) wrote that he had had some experience with goaf-blasts in the United States; however, the goaf-blasts were not of so serious a character as those described by Mr. Thomas Adamson as occurring in the Giridih coal-field. The greatest damage resulting from goaf-blasts at any one time, in his experience, was

the blowing-down of a trap-door and two or three wooden stoppings. Ordinarily, the goaf-blast only created a heavy draught and raised the dust; however, in a gaseous and dusty mine this would be a serious matter, and might probably result in a disastrous explosion.

The heaviest goaf-blast in his experience occurred at the time of the second breaking of the roof-measures in drawing pillars. He had noticed that when rib-drawing followed a long line with a comparatively narrow goaf, the resulting goaf-blast was light; and that when the goaf was wide compared with the length, the resulting goaf-blast was correspondingly strong. The seam of coal, in this case, was about 8 feet thick, and free of slate or refuse. The immediately overlying stratum ranged from 4 feet to 20 feet in thickness, and was composed of roof-coal, fire-clay and friable slates; over this was a heavy bed of very strong sandstone. The remainder of the cover consisted of limestones, shales and sandstones. The thickness of the overlying strata ranged from 400 feet to 600 feet. He further noted that the goaf-blasts were strongest when the sandstone was nearest the coal. This he ascribed to the fact that where the friable roof-stratum was thick, it crumbled down to such an extent that it formed a cushion for the sandstone to settle upon, and it also closed the goaves to a certain extent, therefore, there would be no large body of air to be displaced when the fall of sandstone took place. After a long line of goaves had been established, goaf-blasts did not occur in any case within his experience.

In the cases cited by Mr. Adamson, the coal, including its parting of sandstone, measured fully twice as much in thickness as the seam to which he (Mr. Keighley) had referred. This, of course, would form a very large air-space as the pillars were taken out. He (Mr. Keighley) further noted that there was no friable material to fill partially the space formed by the removal of the coal, or to form a cushion to break or lighten the fall of the very heavy sandstone immediately overlying the coal-seam. The goaves, formed by the pillar-drawings described by Mr. Adamson, were in one case nearly one-half as wide as the length, and in another case, three-fourths of the length. He (Mr. Keighley) was of opinion that the three factors, namely:—Thick coal (16 feet); heavy sandstone, immediately overlying the coal (42

feet); and the comparatively wide goaf, would fully explain the abnormal goaf-blasts described by Mr. Adamson.

It was not surprising that the blasts were so destructive: the large body of air within the goaf must necessarily be driven through the narrow galleries of the mine at high velocities, when it was almost instantaneously compressed by the fall of the sandstone, 42 feet thick, through a perpendicular distance of 16 feet. The air-pressure thus set up could almost be calculated, as the factors of space, weight, fall and frictional resistance could be readily found. These latter comments, however, compared with the possible prevention of such goaf-blasts were not of importance, and, therefore, he would not dwell further on that line of thought.

Taking up the particular question of the goaf-collapses at the Kurhurbaree colliery, he was of opinion that the *chowkidars*, 8 feet square, undoubtedly accentuated the difficulty in a great measure; that was, they prevented the sandstone from breaking until a large area of goaf had been formed. He was of opinion that the dangers from goaf-blasts might be much lessened, if not entirely prevented, by adopting the following lines of action:—(1) The line of pillar-drawing should be made as long as possible. (2) The width should be minimized as far as possible. (3) Before the line of rib-drawing was fairly begun, a central line of holes should be drilled into the roof, 4 feet or more in length, parallel to the line of pillar-workings, and when sufficient space had been formed to enable explosives to do good work, the holes should be charged with strong explosives and the sandstone-roof broken by the force, thus opening up a line of fracture that would rapidly work upward, of its own volition, as the weight increased. (4) The *chowkidars* should be blasted away as often as possible.

The objections to this course of action were as follows:—(1) In a gaseous mine, such blasting of the roof would be dangerous, unless special precautions were taken; but such blasting of the roof could be done with safety in a fiery mine, if proper explosives were used and a right line of action was adopted. (2) It would cost a considerable amount to drill the holes and to fire them; however, the cost of such work would be as nothing, compared with the uncertainty of working and the damages resulting from heavy goaf-blasts, such as those described by Mr. Adamson.

He (Mr. Keighley) was at some disadvantage in making his suggestions, as factors undoubtedly existed that were not mentioned in Mr. Adamson's paper. However, on the whole, he was of the opinion that the force of goaf-blasts could be much lessened by the introduction of such measures as those now crudely described.

He (Mr. Keighley) further noted that it had been the practice heretofore to cut the coal-field, as it was being worked, into square panels of various dimensions. This he believed to be a mistake where so great a weighting of the roof was encountered, and he would suggest that the coal be kept as solid as possible until the rib-drawing had been under way for some time and the initial breaking of the sandstone had taken place.

The method now being adopted on the coal-property under his (Mr. Keighley's) management, where heavy weighting of the roof-measures was likely to occur, was to divide the coal-field into panels, 1,000 feet or more in width, and only drive such narrow or development-work as was absolutely necessary to reach the rear-end of the panel, or in some cases, the boundary of the coal-field. When the starting of a line of rib or pillar-work was determined upon, the arrangement of the pillar-line was such that it extended across the ends of two or more panels, thus making a line, 2,000 to 3,000 feet in length, in which distance there were only two or three pairs of headings or narrow workings. Under this system, there could be no danger of the weight riding over the coal-panels.

The CHAIRMAN (Mr. J. S. Dixon) moved a vote of thanks to Mr. T. Adamson for his paper.

Mr. C. C. Leach seconded the resolution, which was cordially approved.

Mr. C. C. LEACH proposed a vote of thanks to Mr. J. S. Dixon for his services as chairman of their meeting on that day.

Mr. S. F. WALKER seconded the resolution, which was cordially approved.

DISCUSSION OF MR. A. A. ATKINSON'S PAPER ON "WORKING COAL UNDER THE RIVER HUNTER," ETC.*

Mr. A. A. ATKINSON (Sydney, New South Wales) wrote that the conditions of working the Bore-hole seam, under the Hunter river and Pacific Ocean in the vicinity of Newcastle, are somewhat severe, owing to the comparatively shallow depth at which the coal is found below the water, and to the presence of thick alluvial deposits overlying the seam, as well as to the disturbing effects of basalt-dykes, many of which have been found in the workings of the collieries. It was satisfactory to have expressions of opinion from local mining engineers on the methods of working adopted; it was unfortunate, however, that Dr. Robertson was inaccurate in some of his statements, and to those he proposed in the first place to give his attention.

Respecting the strata overlying the Bore-hole coal-seam, at the Hetton and Wickham and Bullock Island Collieries, adjacent to the Dyke, Dr. Robertson stated that the seam "was overlain by only a few feet of solid strata,"† whereas a reference to the sections of these shafts‡ discloses the fact that there is a thickness of no less than 45 feet of rock, a fairly hard sandstone, which has been sufficient to ensure the safe working of the abovenamed collieries, without damaging the surface in the locality referred to.

The depth to the Bore-hole seam at the Inner Nobbys is said to be "about 155 feet under high-water mark."§ This is a misleading statement, for the bottom of the Bore-hole seam (the only one worked at these collieries) as proved by the bore-hole near the Nobbys, was found at a depth of 313½ feet from the surface; and, as the top of the bore-hole is 12 feet above high-water mark, this leaves the bottom of the coal at 301½ feet below high-water mark,‖ a figure nearly double the one mentioned by Dr. Robertson.

The following statement is also made:—"In connection

* *Trans. Inst. M. E.*, 1902, vol. xxiii., page 622; 1903, vol. xxvi., page 254; and 1904, vol. xxviii., page 130.

† *Ibid.*, 1904, vol. xxviii., page 132.

‡ *Ibid.*, 1902, vol. xxiii., No. 7 section, page 655; and No. 14 section, page 658.

§ *Ibid.*, 1904, vol. xxviii., page 132.

‖ *Ibid.*, 1902, vol. xxiii., page 656.

with this subject, it is fitting to mention that the workings of several of the inland collieries communicate with those undermining the ocean-bed, so that a possible catastrophe would not be confined to one, but would, in all probability, extend to several collieries. The dire effects would be far-reaching."* It might reasonably be inferred that the preceding reference was intended to convey the impression that no barriers were left between the collieries mentioned in the paper; but this is not correct. As a matter of fact, all the collieries are separated by barriers of coal, varying in thickness from 100 feet to 264 feet, and a considerable area of the workings has been verified by surveys made by a competent surveyor of the Department of Mines.

Dr. Robertson quoted his (Mr. Atkinson's) statement regarding the "igneous dyke at Nobbys,"† and then referred to the latter as "two prominent stratified eminences that guard the southern entrance of the harbour." Dr. Robertson then adds, "as a matter of fact, however, 'a basalt-dyke' with a north-westerly trend, intersects both the Outer and Inner Nobbys, and there are suspicions of another in the shallows between these points, while at comparatively short intervals to the south, several basalt-dykes intersect the shelving sea-beach and sea-cliffs."‡ He (Mr. Atkinson) had never previously heard of "the Outer and Inner Nobbys," and he therefore made inquiries of the Engineer-in-chief for Harbours and Rivers, who stated that these distinctive names were absolutely new to him. On a lithograph of the original survey of Newcastle harbour, the point or hill under discussion is named "Nobby Head," while the nearest part of the mainland is named "Fortification Hill"; and shown as "Signal Hill" on his (Mr. Atkinson's) plan.§ According to the highest authorities, therefore, there are no "Outer and Inner Nobbys," and, as a matter of fact, "Nobbys," or "Nobby Head" is an isolated, more or less, circular hill, composed of the Upper Coal-measures separated from the mainland (though now joined thereto by a causeway) by marine denudation. He (Mr. Atkinson) was aware that numerous dolerite-dykes intersect the Coal-measures to the south of Nobbys; they can be plainly seen in the cliffs as well as in the

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 135.

† *Ibid.*, 1904, vol. xxviii., page 132.

‡ *Ibid.*, 1904, vol. xxviii., pages 132-133.

§ *Ibid.*, 1902, vol. xxiii., Plate XXX., page 660.

rocks forming the shore, but he must confess to being in doubt as to what Dr. Robertson means by "suspicions of another in the shallows."

Referring to the limits of submarine workings under the German Ocean, it is stated that a seam 3 feet thick is worked under a minimum thickness of 300 feet; and a similar seam, under a minimum thickness of 270 feet of solid strata; and further, that in this area, "the bed of the ocean consists . . of stiff bluish clay, while there are no basalt-dykes, and faults are few."* It is fair to mention that in these cases the seam is worked on the longwall system, whilst all the mining operations described in his (Mr. Atkinson's) paper are conducted on the bord-and-pillar system, the pillars being left to support the roof, thus very materially diminishing the chance of any subsidence reach- the bottom of the ocean or river.

In alluding to the longwall working at Cowpen colliery, Mr. T. E. Forster stated that "the limit of cover, up to which the whole of the coal may be removed, under the Newsham lease, is fixed at 300 feet, and there are provisions for exploring in advance of longwall workings and leaving barriers against the main roads of any bord-and-pillar workings."† There was evidently, therefore, in this case provision for working bord-and-pillar at a less depth than 300 feet, and beyond the long-wall workings, provided that pillars were left, but of this Dr. Robertson made no mention. With regard to clay on the bed of the ocean, Mr. T. E. Forster mentioned that "they had for a long distance from 40 to 80 feet of clay, all along the coast [of Northumberland], but beyond a trouble it disappeared." Mr. T. E. Forster also stated that "it was always best in fixing a limit to leave the clay out of consideration altogether,"‡ and he (Mr. Atkinson) concurred in that opinion.

It was stated that "the ocean-bed, so far as he (Dr. Robertson) is aware, consists of sand and comminuted fragments of shells, etc."§ This bald statement, without any qualification, leaves it to be inferred that the above is the general character of the ocean-bed near Newcastle, where submarine mining is conducted. This statement is shown to be incorrect by the

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 133.

† *Ibid.*, 1902, vol. xxiv., page 428. ‡ *Ibid.*, 1902, vol. xxiii., page 662.

§ *Ibid.*, 1904, vol. xxviii., page 133.

sections of Nos. 1, 3 and 4 bore-holes made, near high-water mark, by the Australian Agricultural Company,* as there is an entire absence of sand in the sections. To the south of the river Hunter, the same information has been obtained from ocean-soundings, as well as from the practical experience of fishermen and bathers along the coast. To the north of the river Hunter, the character of the ocean-bed is more uncertain, and there are considerable depths of sand along the Oyster-bank. It might be explained that, under this portion of the coast, no coal had been won where there was less than 230 feet between the top of the seam and the bed of the ocean. All workings to the north of No. 43 bord† were stopped about two years ago. Recent bore-holes put into the roof for a distance of 30 and 60 feet above the seam in the ocean-workings of the Stockton colliery have proved sound strata, mostly composed of sandstone.

Some explanation may be necessary in reference to the comment by Dr. Robertson that "the author stated that the Department of Mines stipulated for a thickness of 120 feet of strata, above the ocean coal to be worked. No reasons are adduced for this limit of thickness, so much less than that considered necessary in Great Britain."‡ The quotation referred to in his (Mr. Atkinson's) paper was as follows:—"For the present, therefore, it has only been deemed necessary in the case of the submarine workings of the Newcastle Coal-mining Company to decide upon the minimum thickness of strata to be left between the bed of the ocean and the coal-seam, and this has been fixed at 120 feet."§ It will thus be seen that there is a considerable difference between this statement and the form in which it appears in Dr. Robertson's comments. Since the paper was written, the Australian Agricultural Company have decided to explore a portion of their sea-coal to the 120 feet limit, with the view, if possible, of working to that point. This is being done with the sanction of the Department of Mines, and under the advice of Mr. T. E. Forster, consulting engineer to the company, who has had a very large experience of submarine working. Reference has already been made to the

* *Trans. Inst. M. E.*, 1902, vol. xxiii., pages 652 and 653.

† *Ibid.*, Plate XXX., page 660.

‡ *Ibid.*, 1904, vol. xxviii., page 133.

§ *Ibid.*, 1902, vol. xxiii., page 635.

present thickness existing between the seam and the bed of the ocean in the workings of Stockton colliery; and, in regard to further developments at other collieries, the minimum limit will only be fixed after careful consideration of the local conditions.

With regard to the latter part of Dr. Robertson's criticism as to the limit of thickness being so much less than that considered necessary in Great Britain, it is unfortunately necessary to repeat what has already been stated in his (Mr. Atkinson's) paper, in order to show that the limit in some instances in Great Britain is little more than what has been decided upon here. It would be interesting to know why 126 feet had been fixed as the minimum thickness of cover for the submarine workings at Harrington colliery, off the coast of Cumberland, as Mr. T. E. Forster stated that the conditions were very similar to those mentioned in his (Mr. Atkinson's) paper.* Again under the Firth of Forth, a seam 3 to 4½ feet thick has been entirely removed on the longwall system, with as little as 137 feet below high-water mark.† There is a considerable thickness of clay overlying these workings. In a matter of this sort, we can only be guided by the results of past experience and a careful consideration of local conditions, which have so far been the guiding elements in this question.

It may be mentioned that, as the result of statements made by Dr. Robertson before the Public Works Committee of this State, the Department of Mines asked him to supply any suggestions that he might think necessary to ensure the safe working of these collieries, but up to the present time nothing of this nature has been received. In connection with this matter also, it seems a reasonable question to ask why the Royal Commission which reported in October, 1886, on these and adjacent collieries (and of which Dr. Robertson was president) made no particular reference to this very important matter.

Further on, Dr. Robertson stated that—"At the Australian Agricultural Company's Hamilton collieries, the depth of this sand nearly approaches the horizon of the coal-seam; and, in all probability, this depth will be continued seaward. He (Dr. Robertson) is not aware that the depth of this sand has been

* *Trans. Inst. M. E.*, 1902, vol. xxiii., page 663.

† *Ibid.*, 1897, vol. xiv., page 248.

accurately ascertained on the sea-coast or under the ocean, which is leased for working coal."* Nos. 2 and 5 sections† show that in the former there are 38 feet of sand, and in the latter (the only colliery belonging to this company, now at work near Newcastle) there are 37 feet 10 inches of alluvial deposits above the first coal-seam, whilst the depth to the top of the Bore-hole and working seam is 264 feet 4 inches. It has already been pointed out that the bore-holes along the foreshore of the sea-coal had proved the entire absence of the large deposits of sand referred to in the preceding quotation. Moreover, in order to test the strata in the supposed old estuary of the river Hunter, a bore-hole was put down in 1902 at the instance of the Government geologist and himself (Mr. Atkinson) on the coast-line.‡ The details of the section are given in Table I.

TABLE I.—SECTION OF STRATA IN NO. 1 BORE-HOLE AT MEREWETHER.

No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.	No.	Description of Strata.	Thickness of Strata. Ft.	In.	Depth from Surface. Ft.	In.
1	Sand	16	0	16	0	9	Shaly sandstone ...	43	3	144	6
2	Clay	12	0	28	0	10	COAL	0	9	145	3
3	Clay and ironstone-boulders	1	0	29	0	11	Shaly sandstone ...	1	6	146	9
						12	COAL	7	6	154	3
4	Clay-shale	24	0	53	0	13	COAL, with bands ...	7	3	161	6
5	Shaly sandstone ...	16	9	69	9	14	Sandstone	1	0	162	6
6	Sandstone	4	6	74	3	15	Grey shaly sandstone	2	6	165	0
7	Sandstone, with soft bands	9	6	83	9	16	Grey sandstone ...	4	6	169	6
						17	Conglomerate ...	3	6	173	0
8	Soft shaly sandstone	17	6	101	3	18	Grey sandstone ...	13	0	186	0

In several places, Dr. Robertson makes reference to the proximity of sand and gravel to the roof of the seam, and to the fact that considerable quantities of salt-water have been tapped at one of the collieries. The only place where sand and gravel have been found in workings under the ocean was at Stockton colliery, about two years ago, and, in consequence, the district, already named, to the north of No. 43 bord, was stopped, and is now standing. The sand and gravel referred to in this case were found after a fall of roof had taken place, at the bottom of a bucket into which the water, given off from the roof after the fall, was dropping. On the river-side of the peninsula, sand, clay and water-worn gravel have been found

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 134.

† *Ibid.*, 1902, vol. xxiii., pages 652 and 654.

‡ The bore-hole is situated on the coast-line, about 130 feet north of two faults, west of the word barrier, and near point F, on Plate XXX., *Trans. Inst. M. E.*, 1902, vol. xxiii., page 660.

within a few feet of the coal-seam, so that by means of the colliery-workings the width of the old river-channel has been fairly well located. As already mentioned, all the workings to the extreme north of the Stockton colliery have been stopped, and it is known that the character of the strata to the south of the old channel is much more reliable.

It may be mentioned that the Wickham and Bullock Island colliery, having exhausted the coal under lease, is now about to cease operations; and that the Newcastle Coal-mining Company have now reached the 120 feet limit in their ocean-winnings, and are only working on the landward-side of the points reached by that limit, except in the case of two winning-places being driven sea-ward.

Some other matters referred to by Dr. Robertson have already been answered by Mr. W. Humble in his contribution to the discussion on his (Mr. Atkinson's) paper.

Mr. W. B. Pendleton, in his remarks, referred to "the comparatively narrow margin of security, given by the limited thickness of cover in every instance."* The thickness of strata overlying the seam in the workings of the collieries near Newcastle at the time that the paper was written, varied from 120 to 300 feet, so that it might be assumed that Mr. Pendleton included even the latter thickness of 300 feet as affording a "narrow margin of security." If this be the view intended to be conveyed, and had it been carried into effect, none of the coal won from these collieries under the river Hunter or the Pacific Ocean could have been wrought. The effects of erosion in sub-marine mining may become of paramount importance, but, unfortunately, Mr. Pendleton did not make any suggestions affording additional security to the underground workings where such had taken place—that of boring into the roof to test its character had already been referred to, and geological sections had been made along the coast wherever it had been thought that they would act as useful indicators of changes in the strata.

In regard to the width of the working-places, referring to Mr. Thomas Bell's remarks, Mr. Pendleton stated that "such a reduction from 24 feet to 12 feet was certainly in the correct direction to secure safety."† As none of the working-places

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 138.

† *Ibid.*, 1904, vol. xxviii., page 138.

under the water are more than 18 feet wide, the reference to 24 feet was evidently a mistake.

As to refilling the wastes with sand, whilst this would afford considerable support to the roof and pillars, after the excavations had been made, it could not guarantee the "almost absolute security" referred to, inasmuch as the system proposed could only be resorted to after the excavations had been made, and whatever danger there may be is encountered in the process of making the excavation. The "flushing of culm" into some of the collieries in the United States appears to have been carried out in order to prevent "crushes" or "creeps," where the pillars have been left too small to support the superincumbent strata, and also as a means of disposing of the large heaps of culm or small coal, where there is a difficulty in otherwise disposing of it. If the old workings could be economically filled with sand in the way suggested by Mr. Pendleton, there could be no doubt as to the support that it would afford, and the idea might therefore be commended for the careful consideration of the colliery-managers working coal under the river Hunter or the Pacific Ocean, with some of whom indeed it has already been discussed.

He (Mr. Atkinson) would refer the members to the "special conditions in leases for working coal under the sea," which are observed as far as practicable;* and in addition, it may be mentioned that a Government surveyor is frequently engaged in making surveys of the workings, and in taking levels in order to ascertain the thickness of the strata at various points in the ocean-collieries.

Finally, it would be most valuable if any reasonable method of ascertaining the depth of the sand on the bed of the ocean, a matter which has been referred to more than once in Dr. Robertson's remarks, could be adopted, as hitherto it has not been possible to ascertain this depth with any degree of accuracy; and if any good suggestion towards this end could be made, the Department of Mines of New South Wales would receive it with pleasure.

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* *Trans. Inst. M. E.*, 1902, vol. xxiii., page 639.

DISCUSSION OF PROF. R. A. S. REDMAYNE'S PAPER ON "THE MINING DEPARTMENT OF THE UNIVERSITY OF BIRMINGHAM."*

Mr. W. E. LISHMAN (Durham) said that the lengthy discussion to which Prof. Redmayne's paper had given rise, was evidence in itself of the growing importance with which the training of the intending mining engineer was now universally being regarded. It was not before time that we in this country were becoming alive to this importance. With the completeness (almost to lavishness) of the University outfit no one could quarrel, and with regard to the curriculum he (Mr. Lishman) was in the main in agreement with Prof. Redmayne. It was in regard to the relative importance of theory and practice, and the precedence in point of time that one should take over the other, that opinions were most divided. He had long been of opinion that mining should be placed on a more scientific basis than had, until comparatively recently, been the case; and, in this respect, it had undoubtedly barred its own progress. It had been too exclusively regarded from the practical point of view, and the theoretical side had been correspondingly ignored. The "good pitman" idea, as the one qualification, too rigidly held the field, and even now died hard. It had served its day, no doubt, well, and was still an element entitled to every consideration; but, in itself, it neither met the spirit of the times nor the more complicated methods of modern mining, arising out of altered conditions, such as increased depth, thin seams, new appliances, the introduction of electricity, and so forth. These new conditions called forth a new class of men, and unless they were supplied Britain must necessarily fall back in the industrial race. Mining had advanced beyond the stage of being simply an art, and was now fully entitled to take its place as a science: its career as an art having brought out those principles upon which it was now based as a science. But there was a danger of going to extremes, especially where new ideas were concerned. And just as at one time practice was everything, now that the pendulum was swinging in the opposite direction, it was, at least, desirable to see that it did not swing too far. The problem, in fact, was so to adjust the relationship between theory and practice as to con-

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 465.

duce to the greatest efficiency. The point as to whether a student should start colliery-work or go straight to the University should be well considered. Prof. Redmayne seemed to favour a preliminary year's pit-work. Personally, he (Mr. Lishman), although he was open to conviction on the point, was rather inclined the other way, as it was more in natural sequence to a school-education and the mind was more likely to be receptive to theoretical training. If the four, (or, say, three) months of the summer-vacation of the first year were occupied in pit-work, it would be a means of gradually "breaking" the student into practical work, and would at the same time form a tangible connection with the first year's instruction in science. And, in respect of this long vacation, he (Mr. Lishman) was inclined to endorse the remarks of Mr. Longden.* He was aware of the field-work done during this time (in every way desirable), but still a period of four months would appear to be needlessly long. The museum, as described by Prof. Redmayne, was a valuable accessory, and a well-equipped laboratory was one of the best means of illustrating theory in practice. The impetus given of late to scientific mining instruction was bound to raise the status of mining as a profession, and this in itself would be found advantageous. It will now be more likely to attract to its ranks men of a scientific bent, and this was the class of men who would be more and more required in the future.

Mr. S. F. Walker proposed a vote of thanks to Mr. H. C. Peake for his services as chairman of their meeting on that day.

Mr. C. C. Leach seconded the resolution, which was cordially approved.

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* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 511.

THE INSTITUTION OF MINING ENGINEERS.

GENERAL MEETING,
HELD IN THE ROOMS OF THE GEOLOGICAL SOCIETY, BURLINGTON HOUSE, LONDON,
JUNE 2ND, 1905.

MR. J. S. DIXON, PAST-PRESIDENT, IN THE CHAIR.

Messrs. W. C. BLACKETT and R. G. WARE's paper on "The Conveyor-system for filling at the Coal-face, as practised in Great Britain and America" was read as follows:—

THE CONVEYOR-SYSTEM FOR FILLING AT THE COAL-FACE, AS PRACTISED IN GREAT BRITAIN AND AMERICA.

BY W. C. BLACKETT AND R. G. WARE.

PART I.—BY W. C. BLACKETT.

One of our late Presidents, many years ago, in commenting upon the vast and numerous strides which had taken place in the art and practice of mining, observed how copious was the field yet to be opened out, and in the decades which have passed since then, with all their wonderful advances in practical science, it has been seen that greater progress has immensely widened the sphere for improvements and adaptations.

In no direction has more advance been made than in labour-saving devices, and coal-mining has not been backward in the march. So marked indeed has this been that the *Final Report of the Royal Commission on Coal-supplies* of 1905, in specially considering the minimum thickness of workable seams, has credited coal-cutting machines with greatly reducing the difference in value between thick and thin seams, and has concluded to take 1 foot thick as the minimum basis for the purposes of calculating the coal yet remaining to be worked.

Later on, the Royal Commission sets forth the chief advantages of coal-cutting machines, and as the writer will claim most

of these also for the machinery which he is about to describe, the members may not regard them as too tedious for repetition:—

Advantages of Coal-cutting Machines.—Briefly stated, the chief advantages of coal-cutting machines are, according to the evidence:—(1.) That an increased percentage of large coal is obtained, and the coal got is in a firmer and better condition. (2.) A more regular line of face is obtained, which facilitates ventilation and leads to more regular and systematic timbering, and the weight being more regular and uniform the roof can be more easily kept up. The greater rapidity of working also tends to keep down the cost of repairs, and causes less damage to overlying seams and the surface, the subsidence being more even. (3.) The regular and systematic working tends to increase the safety of the workmen. (4.) Seams, which either because of their thinness or hardness, or both, could not be worked at all, or could only be worked at a profit in good times, can be worked profitably by machines. (5.) Holing is less frequently done in the coal and, when it is, there is much less "small" made than in the case of holing by hand. (6.) The output is increased, and is more regular, and the work is more easily superintended. Fewer explosives are used for getting down the coal; in some cases none. Generally machine-work is less costly than hand-work, especially in thin seams. According to one witness, the saving is much greater in the narrow work or headings than in the longwall faces. From the point of view of the men the work is safer and easier, and the wages are better. The importance of lightening the labour of the men will probably be more appreciated as the working-places become deeper and the temperature becomes higher.*

The adverse conditions are set out as follows:—

Conditions adverse to the Use of Coal-cutting Machines.—There are, however, certain conditions under which machines cannot at present be worked to advantage; viz., where the roof or floor is bad, where there are numerous faults or dykes, or where the seams are highly inclined. So, too, in the case of very soft coal, there is the danger of falls from the face and damage to the machines.†

The *Report* estimates that in 1900 only 17·7 per cent. of the total output of the United Kingdom was obtained from seams less than 3 feet thick. While this proportion has doubtless since increased, it is still a long way off that, according to the Royal Commission, yet to be worked, and which, in Northumberland and Durham alone, is estimated to be, in seams under 2 feet, about 15 per cent., while in the United Kingdom it is about 21 per cent. of the total output referred to.

It is easily seen, therefore, that the demand for labour-saving devices is bound to increase, and nowhere more than in thin seams. This, of course, has been recognized by mining engineers for many years, and while much has been done for cutting coal, drilling, etc., little thought has been given to the filling and transport of the cut coal at the working-face.

* *Final Report of the Royal Commission on Coal-supplies, Part I., General Report*, page 7. † *Ibid.*, page 8.

When therefore Mr. Clarence R. Claghorn, one of our esteemed American members, made a proposal to the writer that they should develop the mechanical conveyance of coal at the face, each to suit the requirements of his own country, the suggestion was at once adopted, and the results have met with very considerable success.* Mr. Claghorn has been prevented from joining the writer, as was intended, in this paper and relating his experience at Vinton colliery, and elsewhere in America, but Mr. Ware has taken his place, although, as American and British practices and conditions vary so greatly, it has been thought best for Mr. Ware to tell his own tale, as he has so ably done, in separate form.

The writer has not rushed in with a paper on the subject until the system has been worked at several collieries, some over quite a long period, as he particularly desired that (so far as possible) others should be able to relate their experiences rather than that he should be unduly suspected of merely grinding his own axe. Although the system, to be described, promises to be most successful in many thin seams, it is not to be concluded that there are no thicker seams where it could be usefully applied. For, although ordinary tubs can be used alongside of the working-face, it yet requires a great width of overhanging roof to be supported, and there is also a good deal of confusion and impediment in the service of tubs to the hewers requiring them. Nor does the writer, on the other hand, contend that every thin seam, or its roof, can permit of the system; but it is certain that there are a great number of struggling collieries which would discover financial salvation by a patient and intelligent endeavour to apply it.

When proof has been adduced that a straight longwall-face of say 250 or 300 feet can be successfully maintained with a reasonable width of cantilever-supported roof-ledge and a reasonable quantity of timber, then the system is worth a trial for the attainment of such success as has already been experienced.

To our cost, we all know that we must provide access to the coal-face, so that tubs may travel for the transport of the mineral; and it is a most adverse fact that, in thin seams, more of such approaching galleries are required than in thick, where the tub can run along the face, while, in the former, height for the

* British patents, 1902, No. 24,167; and 1904, Nos. 3,533, 13,912 and 14,953.

tub to travel can only be got by expensive stone-cutting; and the putting or tramming therein, owing to the natural economy exercised in making such height, becomes increasingly difficult. Moreover, it will not be denied that if there is one personal element of labour more than another which requires persuasion along the paths of daily duty, it is that of the average putter or haulier.

FIG. 10.—SHEET-STEEL TROUGHS.

These indicate some of the labour-items on which the conveyor-system will usually save, but there are others both direct and indirect, while the coal itself is got much larger, and most of the advantages claimed for coal-cutting machines, by the *Report* of the Royal Commission as mentioned above, may equally be claimed for conveyors. On the other hand, too, the conditions which are adverse to the use of the former are also adverse to the latter.

The conveyors in use are driven either by electricity or air (they could be driven by petroleum, in some cases); and it might here be observed that, in many cases, the loss of efficiency in the use of air is largely if not wholly compensated by the greater simplicity of the air-engine, especially in the hands of more or less untrained men.

The conveyors consist of sheet-steel troughs within an angle-iron framework, standardized into 6 feet lengths, the outside face-height being 10 inches and the width 19 inches (Fig. 10).

Each length can be taken down or erected underground, without the use of a nut or bolt; while each trough can be similarly lifted out of the framework for access to the chain beneath. Within the trough is an endless chain of links, specially shaped to convey the coal, and made of carefully annealed and tested steel or cast malleable-iron. The lower half of the chain returns upon suitable runners under the trough, being dragged round by a small tumbler constructed

FIG. 11.—TAIL-END OF A CONVEYOR AND TIGHTENING DEVICE.

so that coal cannot easily lie and be crushed between it and the chain, and returning over a similar tumbler at the tail-end, which is provided with a ratchet-screw tightening arrangement. In addition, the whole tail-end of the frame is moored securely to timber, the mooring-chain being also fitted with a right-and-left-hand screw-tightening device (Fig. 11).

Although the conveyor will work with a considerable curve, it has been found advantageous to strike a line from time to time along the coal-face, to guide the setting of timber for the coal-cutter fenders, or for the hewers, as the case may be, and at the same time to ensure a straight conveyor-frame, as well as a coal-face.

The electric motors may either be three-phase or continuous current, and the speed is reduced to that of the tumbler by means

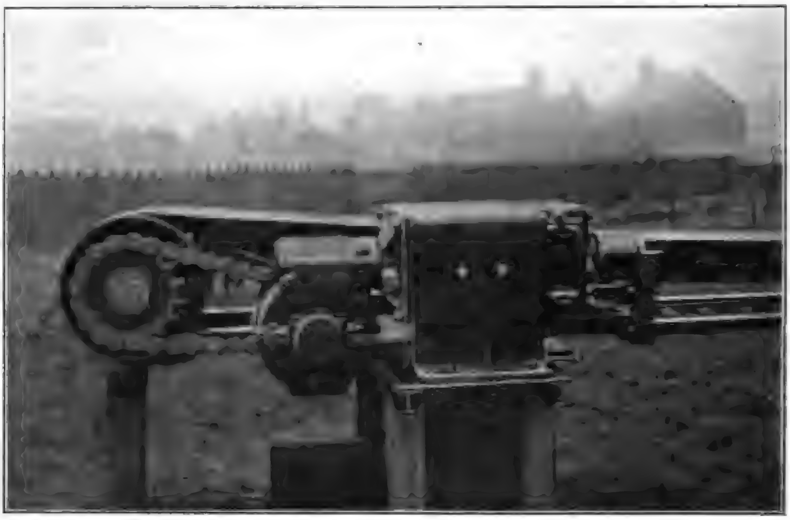

FIG. 12.—CONVEYOR WITH WORM-GEAR AT THE DELIVERY-END, COMPOUND-WOUND MOTOR, BALL-THRUST-BEARING, RENOLD CHAIN, SPROCKETS AND SHEARING DEVICE.

FIG. 13.—DELIVERY-END AND DOUBLE-REDUCTION SPUR-GEAR. THE MOTOR IS PLACED AT THE OTHER SIDE OF THE FRAME, AS SHEWN IN FIG. 14.

either of worm-gear or of double-reduction spur-gear, with a Renold chain and sprockets (Figs. 12, 13 and 14). The worm-

gear is preferred by some on account of its greater silence, but its efficiency, although high for this class of gear, is low. The double-reduction spur-gear is completely enclosed within the head of the conveyor, comparative silence being obtained by filling the gear-case with stiffish grease. The motors are designed to give up to 10 brake-horsepower, and this has been found in practice sufficient to operate conveyors up to 300 feet long, with even the worm-gear, while with spur-gear the work is done by 6 to 8 electric horsepower with ease. The height required for these motors, attached as they are to the delivery-end of the conveyor, is from 17 to 24 inches.

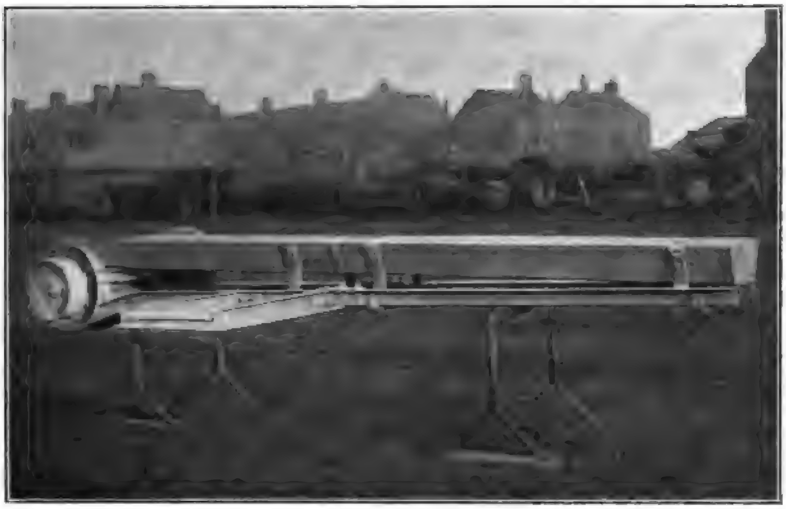

FIG. 14.—DELIVERY-END, WITH PLATFORM FOR THE ELECTRIC MOTOR, WITH A BELT OR, PREFERABLY, THE RENOLD CHAIN-DRIVE AND SHEARING DEVICE.

The compressed-air plant is exceptionally compact, the engine being tucked away into the frame of the conveyor with exactly the same spur-gear as above referred to, the whole not exceeding a total height of 19 inches and an outside width of 33 inches: if necessary the height could be reduced to 14 inches (Figs. 15 and 16).

The engine is completely enclosed, and runs in oil at about 400 revolutions per minute, requiring about 200 cubic feet of free air, that is to say the air exhausted at atmospheric pressure. The engine will work and develop sufficient power with air at a

pressure of 35 pounds, while with 60 pounds it will run up to some 20 horsepower, which is more than double the ordinary requirement.

Should any sudden jam occur in any machinery driven by motors at high speed, the momentum is so great, say in flywheel or armature, that sudden stoppage is impossible without something giving way. The driving force is usually cut off by the melting of a fuse, but that cannot relieve the accumulated momentum of work in the flywheel or armature. It has been necessary therefore to devise a mechanical cut-out, and apply it

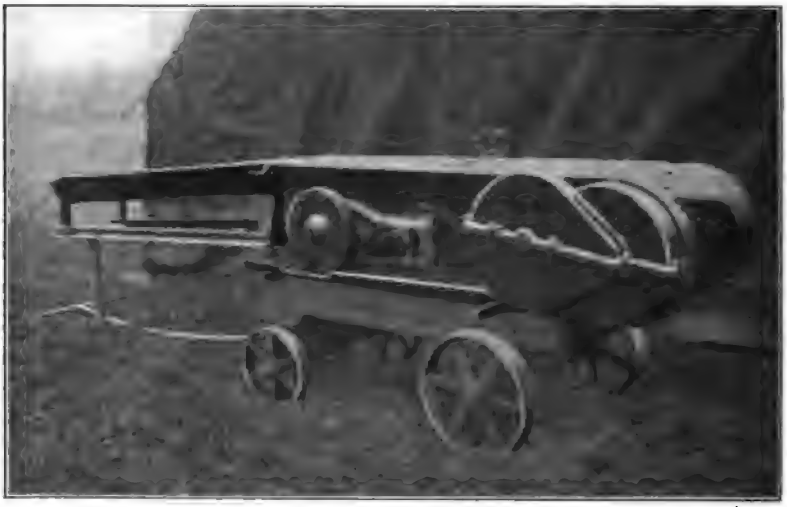

FIG. 15.—DELIVERY-END, WITH HIGH-SPEED COMPRESSED-AIR ENGINE AND DOUBLE-REDUCTION SPUR-GEAR.

to the conveyor-motors. This is accomplished by the use of a coupling on the shaft, one half of which is free to revolve, while the other is driven by a feather-key. A nut on the shaft holds the two halves together against a collar. By interposing a copper key, in keyways cut between the faces of the two halves, the loose half is held and driven. Should, however, a high resistance be met, the copper is at once sheared by the sharp edge of the keyway and the pent-up force is relieved. This, while being simple, has been found remarkably efficient, and incidentally the writer might remark that a similar device would greatly improve some coal-cutters.

The links of the conveyor-chain have many features which

a cursory glance would not reveal. They are readily connected together or disconnected by a special tool, each being held to the other by one long bolt, so designed, however, as not to be subjected to frictional wear which, instead, is placed on the material of the link. Neither the bolt-head nor the nut can turn and become loose, being held by the spring of the link behind the ratchet-projections. The faces propelling the coal are made either square or plough-like, so as to avoid any tendency to mount the small coal, which is further prevented by the weight of the large pieces, while special care has been given to attain comparative silence of running and freedom from frictional noises.

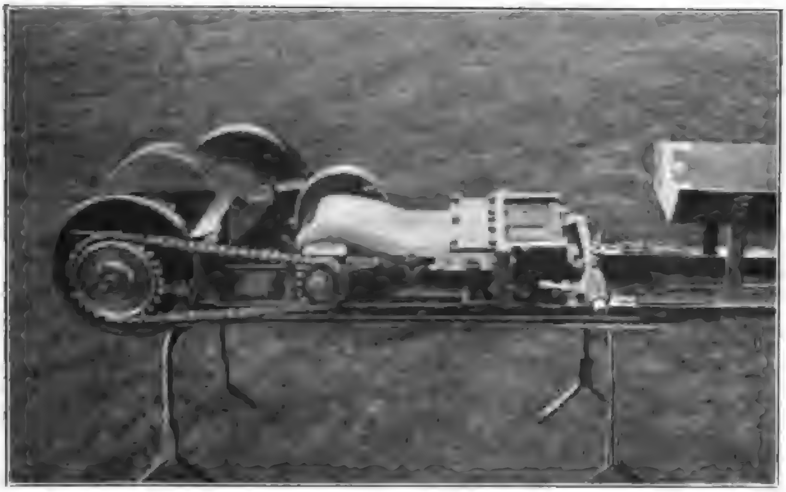

FIG. 16.—DELIVERY-END, WITH TROUGH REMOVED, SHEWING THE ENGINE: THE SHEARING DEVICE IS SEEN ON THE LARGE SPROCKET-WHEEL.

It is astonishing how large a quantity of coal can be delivered over such a conveyor, and 30 tons per hour can be maintained if necessary. Indeed, what strikes a stranger, who first sees the plant at work in a thin seam, is the extraordinary flow of coal pouring out from an invisible source (Fig. 17). To provide for this, it is necessary that there should be a quick succession of tubs, and this requires a gallery to be driven in advance of the longwall-face to serve as a standage for empty tubs (Figs. 1 and 2, Plate XV., and Fig. 6, Plate XVI.). The tramway is preferably double, but it may be single.

While it is quite possible to bring two conveyors, one right-hand and the other left, on to the same gateway, it may perhaps be found better that each gateway should have its own conveyor, all right-hand or left-hand (Fig. 6, Plate XVI.) or back to back (Fig. 1, Plate XV.) as the case may be. The advance gateway may be driven wide enough to provide a pack on its offside, and behind this pack, in some seams, a space which would serve as a stable for the coal-cutter of the next face and as an airway. As has been said before, however, it is quite impossible and indeed inadvisable to lay down any standard of procedure in general terms, because each colliery and seam must develop its own.

FIG. 17.—CONVEYOR DELIVERING COAL FROM A SEAM 2½ FEET THICK, AT KIMBLESWORTH COLLIERY, DURHAM.

To furnish, however, one example, at Kimblesworth colliery, (Figs. 17 and 18) the seam is 2½ feet thick, and the face of coal provisionally 225 feet long. A Diamond coal-cutter is employed, which undercuts on the floor-level to a depth of 4 to 4½ feet. Starting with a ready-cut face, and the conveyor up against it, 3 fillers go in at 6 a.m., beginning at the end of the face where the coal-cutter is waiting for a fresh cut, so that they may clear the coal out of its way. Each filler breaks in a place for himself, every 25 or 30 feet. Four more fillers follow in at

8 a.m., working 8 hours from bank to bank. By 4 p.m., the face is cleared, the fillers having averaged about 11 tons each, besides having set such timber as has been specially necessary.

The coal-cutter driver and his cleaners-out go in at 10 a.m., and by noon ought to be well started cutting on the part of the face cleaned by the fillers.

A workman begins, also about noon, to follow the cutter, drilling holes every 18 or 20 feet, and charges them. Subsequently these are fired by a man in the night-shift.

One boy is employed at the conveyor-head directing the tub filling, and another assists in marshalling and driving the tubs.

At 6 p.m., four shifters go in, who, starting at the end of the face left behind the coal-cutter, draw out the timber in front of

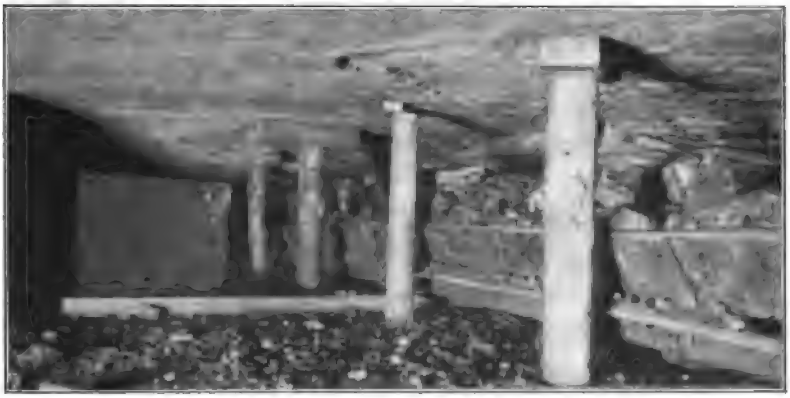

FIG. 18.—SEAM, 2½ FEET THICK, IS UNDERCUT, AND IS BEING FILLED ON TO THE CONVEYOR, AT KIMBLESWORTH COLLIERY, DURHAM.

the conveyor, swing it flexibly and progressively over across the face, or break a joint where found desirable, and re-timber, until the whole is set close up against the newly undercut coal. These are in turn followed by the back-timber drawers, who set up new timber behind the conveyor, and draw out the back timber so as to allow the roof to subside freely. Systematic work and systematic timbering, and complete removal if possible of back timber are all-important.

This rapid and regular advance is found to be of great advantage where a "green" roof provides conditions of stability, which rapidly disappear as the exposure becomes more prolonged.

The following statement gives the cost and other particulars of this work for the fortnight ending April 29th, 1905, being the last pay-table available to the writer.* The pit worked only nine days owing to the Easter holidays, and nine cuts were made and filled, each rather over 4 feet deep. The first (I.) column of costs is calculated upon all the tons got in connection with the No. 1 conveyor-face, both by hand out of gateways and stables, and by

TABLE I.—COST PER TON OF LABOUR ON NO. 1 CONVEYOR-FACE AT KIMBLESWORTH COLLIERY.

No. of Men.	Description.	Duties.	Cost per Ton. I. 899 Tons. s.	d.	Cost per Ton. II. 705 Tons. s.	d.
1	Cutter-man ...	Drives coal-cutter	0	0·96	0	1·23
2	Cleaners-out ...	Cleans cuttings out of cut coal, and casts them back	0	1·49	0	1·89
1	Timberman ...	Sets timber after machine, etc.	0	0·74	0	0·95
1	Shot-firer	Drills holes in cut coal, and charges them	0	0·64	0	0·82
6	Coal-fillers ...	Fill coal away cut by machine	0	5·41	0	6·90
1	Deputy	Charge in day-shift, timbering and keeping work away	0	0·96	0	1·22
1	Supervisor	Charge in night-shift, moving conveyor, drawing timber and stoneman	0	1·17	0	1·66
2	Conveyor-head ...	Attending to filling of tubs and braking the conveyor	0	0·88	0	1·12
7	Stonemen	Working canches in main and tail gates, and putting in packs	0	3·91	0	4·98
4	Conveyor-shifters...	Move timber, and shift the conveyor up to face	0	2·28	0	2·91
3	Timber-drawers ...	Set timber, and draw back timber	0	2·39	0	3·05
6	Hewers	Driving main and tail gates, and making stables	0	4·74		--
1	Putter	Putting coals from hewers ...	0	0·30		—
1	Mechanic	... ...	0	1·06	0	1·35
	Depreciation		0	1·18	0	1·50
	Cost into driver's set		2	4·11	2	5·58

a Diamond coal-cutter, which cuts in the coal; and the second (II.) column is calculated upon the coals dealt with by the conveyor only. This cost may probably yet be reduced by further fixture of piece-prices, and is given more as a matter of interest than as a guide to other seams and other conditions.

* In a later full fortnight, the costs have been reduced 2½d. per ton.

There will be some instances where hand hewing and filling on to the conveyor will prove advantageous in thin seams rather

Fig. 19.—The Coal-face is Standing over the Week-end, ready for the Coal-cutter on the Monday Morning. Temporary Props are set next to the Coal-face. It will be observed that the Roof breaks off behind the Timber, about 11 or 12 Feet from the Coal-face. Yard Seam, 3 Feet thick, Ashington Colliery, Northumberland.

Fig. 20.—The Coal-face is Standing as shewn in Fig. 19. Ashington Colliery, Northumberland.

than cutting by machinery, especially in tender seams; or where stone-kirvings, from under the seam would bury the back timber, and prevent it from being clean drawn.

In conclusion, the writer would remark that several prominent mining engineers in Durham, Northumberland, York-

shire and Wales have now tried the system, and will doubtless add to the interest of this short paper by contributing a discussion of their experiences and economic results; and for this reason he has purposely curtailed many details. All these gentlemen have shown great consideration to the writer in the introduction of the various plants, and he gratefully acknowledges their kindness and skill.

To photographers, it may be useful to know that photographs, from which Figs. 17, 18, 19 and 20 have been reproduced, were

Fig. 21.—Tail-end of the Conveyor. The Deputy is Loading Timber upon the Conveyor, to send it along the Face. A Coal-cutter is seen in the Distance. Newburgh Colliery, Northumberland.

taken by the writer, by means of 200 grains of a mixture of magnesium and sulphur in the proportion of 3 to 1. This was fired on a level with, and just behind, the camera in a train about 3 feet long, so that the elongated flash might soften the shadows.

Part II.—By R. G. Ware.

In order to describe fully the system of working, which is indicated by the title and has been so completely developed in Great Britain by Mr. W. C. Blackett and in America by Mr. Clarence R. Claghorn, the writer feels that he should give some general description of the conditions under which the special application under his direction at Vinton colliery has been made.

The mine is situated in Vintondale, Pennsylvania, working the Miller or B seam of coal, having an average cover-thickness of nearly 180 feet. The territory of the mine is long and narrow, and is bounded on all sides by an outcrop of irregular contour, which together with the heavy pitch encountered, makes the working of the same, by the room-and-pillar system, as employed in this neighbourhood, difficult of successful operation.*

As stated in this paper, it was with the purpose of economically operating the mine, that it was decided to develop on the longwall system, and the faces were worked at the beginning by passing in mine-cars at one end of the face, along the face, and out at the opposite end when loaded. This system was carried on with fair results: the principal difficulties encountered were troubles with the roof and with the steep grades. In the other mines working at Vintondale at this time, no marked slips or cracks in the roof had been noticed, and it was naturally inferred that the same conditions would hold at this mine; but, after the longwall-faces had been in operation for some time, very marked slips were encountered, almost exactly in line with the face, and it was found an extremely difficult matter to keep the roadway open, when these slips occurred at the face.

Another reason for abandoning this method of working was the difficulty of controlling the mine-cars on the heavy grades encountered; there being wrecks, and delays by cars getting beyond the working-places. However, had the roof-conditions been favourable, the proposed method of working would have, with slight modifications, made an excellent arrangement for the use of the conveyor-system.

It was to overcome the many delays and difficulties met with in this method of working, that Mr. Claghorn proposed that a conveyor, constructed and adapted to the purposes in view, should be installed along the longwall-faces, and that the mine-cars be run on a semi-permanent road under the head-end of the conveyor, and there loaded, instead of being passed along the face.

A conveyor was built according to plans prepared by Mr. Claghorn, and the work in the mine was made to suit the

* A description of the mine, and the proposed method of working the same, was read by Mr. Clarence R. Claghorn, at the February, 1900, meeting of the North of England Institute of Mining and Mechanical Engineers, *Trans. Inst. M. E.*, 1900, vol. xviii., pages 351 *et seq.*

required new conditions. From the first, the conveyor was a success, and both conveyor and system have been modified and improved to the conditions as described hereafter.

The coal-territory in the mine (Fig. 7, Plate XVII.) is divided by a main heading and an air-course running practically with the pitch of the coal-seam; this pitch is variable, the average being about 8 per cent. Coal-pillars, 80 feet thick, are left on each side of the main headings.

The coal averages 3 feet 6 inches in thickness, free from slate-partings, and is soft and friable. It is bound very tightly to both roof and floor, and there is practically no parting; this makes it necessary to use a considerable amount of powder in blasting the coal, and the pick is used to an undesirable degree in trimming up the face.

The roof of the seam is a blue slate, about 12 feet thick, overlain by a layer of shaly sand-rock. There are marked slips or crevices in the slate, making an angle of about 22 degrees with the line of the main headings. It is therefore necessary that the line of the longwall-faces should be relatively perpendicular to the slips of the roof-rock, as, when so, the roof is more easily controlled.

The system of longwall here described is a modified system, partly advancing, partly retreating. Instead of pack-walls being used, it is found cheaper and better to use timber-cribs to support the haulage-roads (Fig. 22) and the roof-slate is of such a nature that it can be easily broken and controlled by means of timber-props along the face.

When the work of extracting the coal is started, timber-props are used to support the space made vacant, and a considerable distance in the advancing direction is cleared before the roof becomes heavy enough to fall. This varies from 70 to 120 feet. When it is found that the roof is weighting heavily on the props, they are removed, good solid break-rows are set along the lower side of the conveyor, and the roof allowed to fall in sections until the slate-cover, above the coal, is all down. From this time, until the heavier rocks above the slate begin to settle, great care has to be exercised and good break-rows maintained. It usually takes from one to two weeks for the heavier rocks to settle; after this has occurred, the control of the roof is simple.

In preparing the mine for longwall-faces, pairs of cross-headings are turned off from the main heading at intervals of 500 feet and these headings are driven to the outcrop. A barrier-pillar, 80 feet thick, is left to protect the main headings, and at intervals of 270 feet, block-headings are driven perpendicular to the cross-headings. It is very important that these headings be driven on an absolutely straight line, and sights are advanced by the engineers every 100 feet. If these headings are driven crooked, considerable trouble is entailed in having to shift

FIG. 22.—TIMBER-CRIBS IN A HAULAGE-ROAD.

the conveyor forward or backward. When the block-headings are being driven, they are cut out 20 feet wide, which, deducting the width of the heading, gives a coal-face of 250 feet. The bottom is taken up only on the rib-side, and is made deep enough to give sufficient room for the cars to pass under the conveyor and wide enough to give standing-room for a man when loading cars (Fig. 23). This arrangement leaves a bench for the engine, which drives the conveyor, to rest on, and also leaves room for the longwall-machine at the front-end of the face (Fig. 8, Plate

XVII.). The bottom taken up, if stored on the bench, would be in the way of the lateral movement of the conveyor, hence it is found desirable, in driving these headings, to load this bottom into cars, and waste it outside the mine.

When the blocks of coal for the longwall working have been formed, the conveyor is installed first in the block adjacent to the outcrop, the face is advanced up the hill and the roadway for the cars is protected by timber-cribs until the block has been worked out to about 18 feet from the upper heading. Then, the

FIG. 23.—HEAD-END OF CONVEYOR DELIVERING COAL.

adjacent block of coal near the main heading is attacked, and so on, until the entire coal between the upper and lower headings has been exhausted. When the work of the conveyor has been completed in any section, the heading-rib, and the 18 feet pillar, left to protect the roadway, are drawn back by hand to the main heading.

The mine-cars are served in the upper heading from the main haulage-road, and are run in trips of 10 to 12 under the head of the conveyor, loaded, and passed out into the lower heading to

the main haulage-road, where they are ready to be gathered. This method of handling the cars is accomplished by having mules to pull the cars in from the main heading to the block-heading, at the top of which is stationed a double-drum engine, on each drum of which, is 600 feet of ⅝ inch wire-rope. When the cars are brought to the block-heading, they are let down under the head-end of the conveyor by one rope, and the cars are loaded in their turn. The other rope is brought to the top of the heading, and another trip of cars attached to it. This allows one trip to be loaded while the succeeding one is being gathered, and when the first trip is loaded, it is dropped away

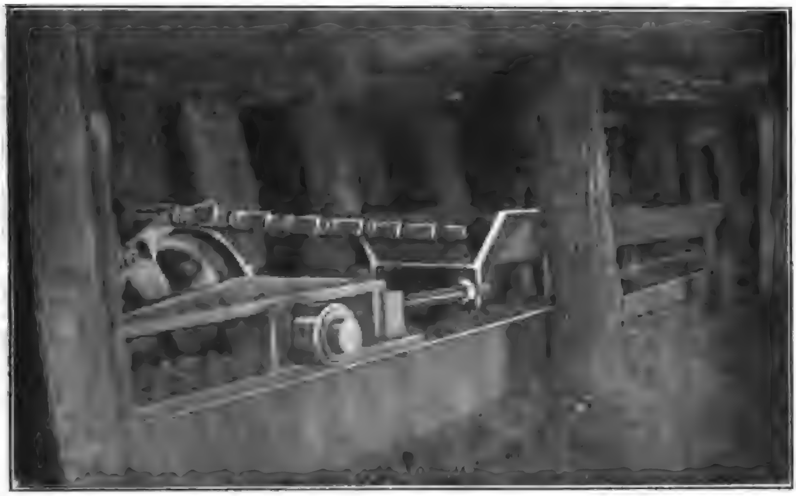

FIG. 24.—REAR-END OF CONVEYOR.

from the conveyor, and the following trip is brought into position. In this way, no time is lost in shifting of trips. Electric signal-wires are run the length of the block-heading, and the man at the head-end of the conveyor signals a boy stationed at the engine, who does the shifting of the cars according to signals given him.

The type-conveyor is a pan, 12 inches wide at the bottom, 18 inches at the top, and 6 inches high. This is supported by strap-iron standards, and a return run-way is afforded below the pan by flat bar-irons. In the pan is run a malleable, winged chain. This chain passes over a sprocket-wheel at the head-end,

which does the driving and returns over another sprocket at the rear-end. Both front- and rear-end are inclined; at the front to obtain height enough to allow the mine-cars to pass under, and at the rear-end to compensate for the necessary size of sprocket-wheel (Figs. 24 and 25).

The conveyors are driven by small double-cylindered air-engines and reducing gearing. The engine and gearing are mounted on a frame, separate from the conveyor proper, and power is transmitted by means of a steel-roller chain to a sprocket-wheel on the drive-shaft of the conveyor.

FIG. 25.—HEAD-END OF CONVEYOR.

The power for operating the conveyor and the longwall-machine is brought through a compressed-air pipe, 2 inches in diameter, from the heading above. This pipe is hung on a line of posts running down the heading, and as the face is advanced up the hill, the pipe is shortened by sections. Connection is made by means of a 10 feet length of a $2\frac{1}{2}$ inches wire-wound hose, from the pipe running down the heading to a second pipe which runs the entire length of the face, and is attached to the conveyor. This conveyor-pipe has outlets with 2 inches stop-cocks at intervals of 48 feet. The hose of the compressed-air longwall-

machine is arranged so that it can be attached to these cocks, an arrangement whereby the machine-runner has merely to carry with him a short length of hose, instead of one reaching the entire length of the face. A pipe, 1¼ inches in diameter, is carried from the end of this conveyor-pipe to the air-engine, which drives the conveyor.

In this line is placed a valve, to which is attached a bell-crank and rod; the rod is run to the head-end of the conveyor and the conveyor-runner controls the operation of the conveyor by opening or closing this valve (Fig. 26).

FIG. 26 —CONVEYOR-RUNNER CONTROLLING THE OPERATION OF THE CONVEYOR.

The longwall-machine used is an improved type of Jeffrey compressed-air longwall-machine, front and rear views of which are shown in Figs. 27 and 28. The machine cuts at the floor-level, and is arranged so that it can be raised or lowered at either end to conform to the contour of the floor, by raising or lowering the track-wheels. This is done by means of a square-threaded screw turning in the frame, which carries the track-wheel, and bearing in a casting which is attached to the machine.

The machine is made to cut in both directions, and the reversing of the same is effected in shifting the eccentric by an ingenious method of having a screw attached to the eccentric-slide in the slot of a casting, keyed to the drive-shaft. The head of this screw is larger than the screw-body, and fits in a bored-hole made to correspond to the proper position of the eccentric, for either forward or back movement of the machine.

The drill, used by the shot-firer for drilling holes is very light and compact. The total weight of drill and auger does not

FIG. 27.—FRONT-END OF JEFFREY COMPRESSED-AIR LONGWALL MACHINE.

exceed 20 pounds. The machine is, in reality a small four-cylindered air-engine, and has a gear on the crank-shaft, which meshes with another gear on the shank of the machine. On the end of the shank is screwed a small chuck, to which the auger is fastened. The power for operating this drill is obtained from the compressed-air pipe running along the conveyor, and attachment is made through a hose, $\frac{3}{8}$ inch in diameter, to the machine. It has been found that the shot-firer can drill a hole, $4\frac{1}{2}$ feet deep, in about 2 minutes from the time that he starts to drill.

In the management and proper handling of men, machinery, and timber, lies the secret of success or failure of this particular

system, and it has been found that the most important factor is the man, styled the "block-boss," who has charge of the long-wall-face, where he is working. This man must be a skilled miner, and possess some executive ability. Under him are six loaders, two machine-runners, one conveyor-runner, and one shot-firer, who also does the drilling. The greater part of the men employed in the mine are non-English speaking; the most satisfactory arrangement is obtained by having an English-speaking man in charge of the block, English-speaking men running the machines, and the balance of the crew, men of foreign birth.

FIG. 28.—REAR-END OF JEFFREY COMPRESSED-AIR LONGWALL-MACHINE.

In preparation for the day's work, the machine-runners have cut a distance of 30 feet, which the shot-firer blasts down; this is usually done on the preceding afternoon, and the machine is left standing in the face until the next morning.

The first thing in the starting of the day-turn, is the loading out of this coal. Five loaders are put at this work, and the machine-runners at the same time start cutting, and continue to the end of the face. Following the runners closely, is the loader, who cleans the slack from the undercut, and loads the same into the conveyor. It takes, on the average, 4 hours to cut 250 lineal feet.

The machine-men, when they have finished their cut, jack the machine up to its proper position for the return-cut, and they then follow the loaders and set up a line-row of small posts at intervals of from 15 to 20 feet against which the conveyor is to be moved. This line-row is set at a distance from the conveyor corresponding to the depth of the undercut that the machine makes, a distance of 4 feet 3 inches on the average. The space left between the line-row and the face is merely wide enough for the machine to get through on its return-cut, or about 3 feet.

Following the machine-men as they cut, is the shot-firer, who blasts down the coal preparatory for the loaders. Of late, the best results have been obtained by using a battery, and firing a series of six to eight shots at one time. When the shot-firer finishes blasting the coal, he goes to the other end of the face and begins drilling the coal with his air-drill, in preparation for shooting the succeeding cut. It is necessary for him to have a number of augers for drilling the entire face, and when one auger has been dulled he merely screws the same out of the chuck of the machine, and replaces it with a sharp one.

Meanwhile the loader, who has been cleaning the cut, after the longwall-machine, joins the other loaders and the crew shift from point to point as they clean the place where they have been working. The coal is conveyed in a steady stream to the head of the conveyor, and there loaded into the mine-cars, which are passed successively under the head of the conveyor. The process of loading and trimming the cars is a simple operation, and needs no further discussion.

When the process of loading has been completed, the entire force of men are set to moving the conveyor laterally to its new position on the face against the new line-row of posts, which have been set by the machine-men, by the time that the loading is finished. This is accomplished by means of any suitable kind of pulling-jack, of which several types are in use.

As soon as the moving is finished, and it occupies very little time, seldom more than 20 minutes, some of the men are set to putting up a new break-row of props, adjacent to the lower side of the conveyor, which they do by putting a cap-piece on a pile of slack, standing a post and wedging it home with another cap-piece on the top of the post, whilst others start drawing the old break-row adjacent to the gob. At the head-end, the conveyor-

runner builds the timber-crib in the heading, and assists with the timber when he has finished this.

When the work of drawing the timber has been completed, the day's work is done, and the crew are ready to start on a new cut.

Several years' experience have proved the advantage of the system, and results have come in their turn. The overhanging ledge has been materially reduced, inasmuch as the conveyor occupies less space than the track-rails previously used, and thus the weight on the gob-timber is reduced.

FIG. 29.—SHOVELLING COALS INTO THE CONVEYOR.

The delay of having one man to finish loading his car and waiting for the man behind him to finish loading his, with the system of running the cars along the face is obviated; for the coal, as soon as it is loaded into the conveyor, is carried forward. The height of the conveyor is small, and the work of shovelling into the same is easily accomplished (Fig. 29).

By means of the conveyors, timber can be distributed along the face. The track under the head of the conveyor can be well laid, as it is of a semi-permanent character.

The mine-cars used for this kind of work can be of large capacity, as they travel in relatively high headings, the cars used holding 30 cwts. level with the top.

The work of the men is concentrated, and the maximum returns can be obtained from each man employed.

It has also been noted that the percentage of large coal is materially increased, and that the men working at this kind of work make higher wages per month than the men working by contract.

A modification of this system will produce the best possible control of the roof, Fig. 9 (Plate XVII.) shows this. It will be noticed that a machine that has a depth of undercut, which equals the space required by the clearance of the longwall-machine line-row, conveyor, and break-rows, produces a condition where the line of break at the face always comes beyond the outside of the break-row, adjacent to the conveyor. Therefore, any tendency for the roof to fall will occur beyond the working-place, the weight on gob-props will be greatly reduced, and the rock will fall in blocks when the timber is removed. At the same time, three-fourths more space will be undercut, than at present, and the dead-work of moving the conveyor, setting props, etc., will be reduced accordingly.

Most persons will ask what are the pecuniary advantages of this system over any other system of working, and it may be said in conclusion, that the record in the past two years of the cost of coal loaded into mine-cars in comparison with the district-price for pick-work, showed a saving of 48 per cent. over the latter method.*

Mr. Joseph Dickinson (Pendleton) wrote that he was glad to see one of the labour-saving devices set forth, especially in relation to the working of thin seams.

An apparently identical proposal was made fully quarter of a century ago by the late Mr. Herbert Fletcher. His idea was to convey the coal from the working-face, and also along the levels and upbrows and downbrows, throughout the entire workings of one of the large and moderately thick seams of the Atherton colliery, Lancashire. The conveyor consisted of sheet-iron troughs with an angle-iron framework, so arranged as to

* The Editor greatly regrets to advise the members that Mr. R. G. Ware died on May 19th, 1905.

run round curves; it was made of a working size, but the introduction into the mine was over-ruled.

One of the advantages of The Institution of Mining Engineers was the spreading of information. In his (Mr. Dickinson's) first report as H.M. inspector of mines in June, 1851, mention was made of the requirements to fit the colliery-viewer and mining engineer for the discharge of his important duties, and he quoted the words used by Sir Henry De la Beche in opening the Mining School in hopes of its removing the cause for regret "to find many a powerful mind struggling with a want of knowledge of what others have accomplished or are now doing. Great as the achievements of uninstructed men have sometimes been, they would have been still greater had correct instruction been afforded them."*

Mr. H. Baddeley (Barnsley) wrote that he entirely agreed with most of Mr. Blackett's statements, and the description of the conveyor and the method of working would be readily understood by practical engineers. A Blackett conveyor was working in the New Hard seam at the Elmley Moor collieries. The greatest difficulty and drawback had been the tendency of the endless chain to mount the coal in the troughs, and thus cause numerous breakages of the links. Some of the plough-like links, referred to by Mr. Blackett, were now on trial: present evidence pointed to their being an improvement on the other links, but he did not wish to express a definite opinion on this point. The nuts, which should, if the links were properly constructed, lock themselves, and refuse to come loose by ordinary working, also proved a source of annoyance by coming off, but these mechanical difficulties might be remedied. Apart from these faults, the conveyor was giving every satisfaction, turning out better coal and considerably reducing the cost of working. Since January 25th, 1905, 103 falls of coal had been filled from the conveyor-face upon 106 working-days for this coal-seam: the missing days were caused by the coal-cutting machine being out of order. Later, 73 falls had been filled on 73 successive working-days, the undercut being 4½ feet deep.

He (Mr. Baddeley) would offer the following suggestions to any member proposing to adopt the conveyor-system. If the

* *Reports of Messrs. Dunn, Dickinson and Morton, Inspectors of Coal-mines*, 1851, page 43.

roof and floor of the coal-seam were considered likely to prove suitable for the successful working of the system, they should be determined that it should succeed, and be prepared to work and personally supervise, for a time, its working. In his own case, great difficulties were experienced at the commencement, but, with perseverance, together with a suitable system of timbering and other improvements learned from experience, the difficulties had been surmounted and long ago ceased to present themselves as formerly.

Mr. William Logan (Langley Park) wrote that the conveyor-system of filling at the coal-face was a fine example of adding another link to the economies that had come into use in the last decade, for transferring the coal from the face to the bottom of the shaft; and, while this device would add to the facilities for working thin seams, it did not follow that it could not be applied to the more economical working of seams over 3 feet thick. Personally, he had not seen the system at work in a coal-mine, but he had seen the apparatus at work on the surface; and for the last two years he had watched its introduction and success at a neighbouring colliery, the manager of which had systematically given him reports of its starting, the difficulties which they had to encounter, inherent principally in the teaching of the workmen who had to deal with the system, and not in the system itself, and their having arrived at a point over 12 months ago when all their difficulties vanished, and now they had a largely increased plant, with more than one continuous trough, each 270 feet long, working smoothly and giving no trouble. This was done in a seam 2 feet 2 inches thick, where ordinary longwall working had been abandoned, owing to the excessive cost of working. The cost was now even more favourable than that quoted by Mr. Blackett in his paper.

The great advantages of this conveyor-system were:—(1) The small width between the face of the coal and the back timbers; (2) the long straight line of 250 to 300 feet, which could always be controlled with regard to the line of cleavage of the coal, and the line of cleavage of the superincumbent strata; (3) the enormous reduction in the number of gateways, with the decreased dead-work in relation thereto; and (4) the larger percentage of round coal over coal filled by hand into tubs at the

face. There were many other and obvious advantages, which he need not point out.

Mr. F. O. Kirkup (Garesfield) said that, at the Consett Iron Company's Langley Park colliery, Blackett coal-conveyors had been in operation for 18 months in conjunction with coal-cutters. The seam was locally known as the Low Main, and had a section of 2 feet 2 inches, with a shale-roof and a hard seggar-and-sandstone thill. The natural conditions were not at all favourable to the use of machinery; but, owing to the hardness of the coal, it became a question of either introducing some mechanical assistance or closing the seam. By using coal-cutters and coal-conveyors, the seam had been converted from a non-paying concern into a profitable undertaking.

At the same company's Garesfield colliery, a Blackett conveyor, 270 feet long, was put to work about 3 months ago, and a second one shortly afterwards. The Brockwell seam, 2 feet thick, lies at a depth of 144 feet, with a roof of black stone, and above that hard post: the thill being fire-clay, 1½ feet thick, overlying a bed of post. In the western districts of this seam, the method of working by ordinary longwall was to take out a panel of coal, 468 feet wide, a main gateway or mothergate being driven in the centre and 6 gateways 36 feet apart, on either side. Cross-headings were driven at intervals of 150 feet, and the station-flat, situated in the mothergate, was moved inbye as each cross-heading was commenced. A basis price of 3s. 4½d. per lineal yard was paid for taking down 2 feet of top-stone and packing the same in the gateways, and 3s. 7d. per yard in the mothergates. A second ripping, 2 feet thick, was afterwards taken down in the mothergates, as the flat was advanced, for horse-height, at a cost of 5s. 3d. per yard. The stonework, inclusive of the present 27½ per cent., cost 10·41d. per ton of coal; the cost of hand-putting was 4d. per ton; and the output per man per shift was 2·80 tons.

In the same district, two Blackett conveyors were working, the coals being delivered to one main gateway, one conveyor being placed about 60 feet in advance of the other. The conveyors were not working in conjunction with coal-cutters, hewers hewing the coal and casting it direct on to the conveyors, whereby it was delivered into tubs standing in the mothergate.

The hewers were cavilled in sets of 20 men to each conveyor, 10 men in each shift. The machinery did not begin working until about 6·30 a.m., and it stopped about 3·30 p.m.

The coal-face, when all the men were at work, advanced 5 feet per working-day, and the conveyors were shifted forward every night: the whole operation, including the drawing and resetting of the timber, being performed by 5 men at each conveyor. The roof was supported upon two rows of hardwood chocks, spaced 4 feet apart, one row being withdrawn each day and reset as the face advanced. Owing to the absence of cutter-kirvings, etc., all the timber was drawn and none was left standing in the goaf, the roof falling freely. Two boys, at the driving-end of the conveyor, attended to the loading of the coal into the tubs. The main gateway was driven 10 feet wide, about 3 feet of bottom-stone was taken up, and about 2 feet of top-stone was taken down. A gateway, 4½ feet high, was driven at the end of each face for ventilating and travelling purposes. The hewers produced, on an average, about 4 tons per man per shift, each face producing about 80 tons per day. The costs were as follows:—Stonework, 2·37d. per ton; shifting the conveyor forward, 5·33d. per ton; boys attending to the conveyor on the mothergate, 1·06d. per ton; making the total cost, 8·76d. per ton. The hewing prices were the same under both systems, but it was evident that the hewers working on the conveyor-faces could afford a considerable reduction.

On comparing the two systems, it was found that, at present, there was a saving of about 6d. per ton in the labour-costs; but no account was taken of the reduction in the costs of timber and stores, a considerable item, owing to the reduced amount of roadways to be maintained and to the fact that the face-timber could be used over again. The amount of saving under this head would probably pay for the maintenance of the plant, the damage up to the present having only amounted to a few broken links. The greatest advantage obtained was the increased tonnage per man per shift, amounting to at least a ton, and this, it need hardly be pointed out, in a seam of that inconsiderable thickness was of the greatest importance. The discontinuance of the putting was also important, as previously on many days the putters were unable to run the tubs, owing to their scrubbing and sticking in the gateways. The faces travelled quicker, and

the men being more concentrated, there was less deputy and other back-bye work. The management were satisfied with the results obtained, and arrangements were being made for the application of conveyors in other parts of the pit.

Mr. HENRY PALMER (Medomsley) wrote that he had read with great interest the paper by Mr. Blackett on the use of the Blackett conveyor in mines, and he now proposed to offer a few remarks respecting the experience which had been gained with these conveyors in the mines under his charge. By far the greatest amount of work with them had been done at Langley Park colliery, where three had been in operation for about 18 months in conjunction with Diamond coal-cutters. The conveyors had proved thoroughly successful, after experience had taught their proper use (more particularly with respect to a correct method of timbering), and had exhibited so distinct an economy in working that, in conjunction with the mechanical coal-cutters, they had converted what was previously an unworkable seam on account of the high cost, into a workable one, leaving a fair margin of profit.

A trial had been made of the Blackett conveyor at the Consett Iron Company's Derwent colliery from June 27th, 1904, to February 4th, 1905. The chief reason for mentioning this example was not for the purpose of producing evidence of any startling success, but quite the reverse. At the same time, it should be clearly stated that the unsuccessful trial was not in any degree due to the fault of the conveyor, but purely to the physical conditions under which the attempt was made to work it; and this would be easily understood when it was stated that the section of the seam decreased between the periods abovementioned from 2 down to 1½ feet, the conveyor under the latter section being quite unworkable. No coal-cutters were used in connection with the conveyor at Derwent colliery. Briefly, the result of the experience with this conveyor was an immediate increase in the output per hewer per shift of 1·6 tons, as between ordinary hand-labour and coal filled into tubs in gateways, spaced 42 feet apart from centre to centre, and coal got by hand-labour but filled into the conveyor. The hewers' wages increased from 5s. 2·61d. to 7s. 2·13d. per shift. In conclusion, he (Mr. Palmer) might add that another Blackett conveyor, of the

newest type, had recently been ordered for this colliery, as he was convinced that, under suitable conditions, it would give a very good account of itself.

Mr. AUSTIN KIRKUP (Herrington) wrote that the Blackett coal-conveyor had been adopted, owing to the peculiar conditions of the Hutton seam at Herrington colliery which made the coal expensive to work. For some years, coal-cutters had been in operation in this seam and the results had been satisfactory as compared with hand-labour, if not in actual labour-cost, at any rate in the increased value of the coal produced. The seam, 2 feet 9 inches thick at a depth of 1,000 feet, was dipping to the north-east at a gradient of 1 in 9. The shale-roof was good at the working-face, until it was broken into for the purpose of ripping gateways. It then became very bad to maintain, and the cost of shift-work for maintaining the gateways was extremely high. In addition, great difficulty was experienced in getting out the men's work, owing to the rough roadways. The under-clay was soft and crumbling, and did not make a good packing-stone; and it was consequently not feasible to make height by ripping in the floor.

Under the above-named conditions it was obvious that it would be advantageous if a system of mining could be devised that would reduce the number of gateways in this seam, without decreasing the output from the face. The Blackett conveyor-system appeared to answer the requirements in this respect and consequently it was adopted. The inclination of the seam (1 in 9) rendered putting a matter of great difficulty, and it was accentuated by the rough condition of the roadways. In establishing a conveyor, it was naturally expected that the cost of putting would be reduced or even abolished. The coal-cutter was arranged to cut on a headways face, on the full dip of the seam. The main gateway leading to the face was therefore on the strike, and consequently level. The conveyor hauled the coals along the face, 240 feet long, dipping at the rate of 1 in 9, and delivered them into tubs in the above-mentioned main level. It was intended to equip another conveyor on the rise side of the main gateway, so as to discharge its coals into the same level. It would then be practicable to work a face 480 feet long, into one haulage-road. There were two gateways, used as return

airways at each extremity of the face: consequently, for a face 480 feet long, three gateways were formed. The conveyors had been at work for 3 months, with the following results:—The produce of the filler had increased from 5·8 tons to 8·5 tons per man, with a consequent reduction in the cost of filling of 2d. per ton. Putting of the coals had been abolished, and this item, owing to hand-putters being employed on such a gradient, cost 4d. per ton. The rate of advance of the coal-face had more than doubled, and the output from that particular district had been increased, with a corresponding decrease in the standing-charges for shift-work, timber, etc. The produce of round coal had increased by 8 per cent., as compared with the yield under the previous system of filling the coal directly into the tubs. This increased yield of round coal was probably due to the fillers not being now required to break the coals, so as to load them into the tubs, to such an extent as formerly. The average output during the past 10 weeks had been 73 tons per day; and on several occasions the output had attained 100 tons per day. The above-named average output had been attained irrespective of the following stoppages:—Two days' complete stoppage, owing to a bad roof caused by the roof breaking at the face. This happened a few days after starting the conveyor, and was due to the first break of the roof taking place in the post-stone, lying 6 feet above the coal-seam. Props were then being used to support the roof at the coal-face, but since then chocks or nogs had been used with satisfactory results. No further trouble had been experienced from breaking of the roof at the face. Two stoppages of 3 hours each, due to the compressed-air motor having to stand on account of defective lubrication. These stops were due to carelessness on the part of the attendant, and not to defects in the air-motor, which was an excellent machine. Occasional stops of about 30 minutes each, were due to breakage of the links of the scraper-chain. The result obtained in this particular seam, where the conditions of roof and dip were peculiarly suited to conveyor-working, were satisfactory; and further extensions of the conveyor-system were contemplated.

It was not possible, owing to their limited experience, to estimate the cost of maintenance of the conveyor; but, up to the present time, only a few broken conveyor-links had required replacement.

Mr. C. H. Merivale (Radcliffe) wrote that a Blackett conveyor had been at work at Newburgh colliery for about a year, and it had shewn that the face could be supported under almost all conditions of bad roof, provided that it were kept moving onward. The conveyor had been shifted through a trouble, with a throw of 3 feet, without mishap, but economy would have been best served if the face had been won out afresh. Where a trouble was cut through by the coal-cutter, the conveyor could follow; or, in other words, the conveyor was quite as elastic as a coal-cutter of the longwall type.

When the seam was flat, 210 feet seemed to be the most convenient length with the present type of chain and motor; but the length of face was dependent on the nature of the holing, that was, the distance that could be regularly cut in about 8 hours of actual running, and this time again might be curtailed or lengthened according to the time needed for the other two operations. The filling of the coals was the simplest part of the procedure, coal-cutting the next, and the shifting forward of the conveyor was the most difficult. The roof was a short blue metal, and a great deal of timber was used. If a really facile break-and-make joint could be devised for the troughing and chain, it would materially reduce the cost of shifting the conveyor forward in many seams. The conveyor had been recently transferred to a new face with a dip of 1 in 7 in favour of the load, and by this means it was hoped that the face might be lengthened to 285 feet, and the output increased to 100 tons daily.

Table II.—Output of the Blackett Conveyor at Newburgh Colliery.

Period.	Days.	Output. Totals. Tons.	Output. Per Shift. Tons.	Period.	Days.	Output. Totals. Tons.	Output. Per Shift. Tons.
1904. July ...	11	346·4	31·5	1905. February	21	589·3	28·0*
August ...	22	954·6	43.4	March ...	23	1,244·1	54·1
September	24	1,046·7	43·6	April ...	17	1,189·6	70·0
October ...	22	1,135·1	51·6	May ...	22	1,615·3	73·4
November	23	1,473·6	64·0				
December	22	1,047·3	47·5	Totals ...	228	11,027·5	48·3
1905. January ...	21	385·5	18·3*				

* Hand-holing and conveyor moved forward through troubles.

The average daily output had been 48 tons since the conveyor was started, and during the last month it was 73 tons daily. The cost of maintenance and repairs for 11 months, including fitter's time, new parts, spares, etc., was 4d. a ton on the 11,028 tons conveyed. This cost was high, owing to the

period having been experimental: moreover, it included new troughing bought to replace those lost under two falls of roof at the face, and a new motor. From the smooth running of the past 3 months, it appeared that 2d. a ton would be ample in the future. It was early as yet to define the life of the conveyor, but the signs of wear were very slight. The only accident that had occurred with the conveyor, was a broken finger, sustained by one of the hewers who had put his hand into the chain.

Mr. E. O. Southern (Ashington) wrote that part of the Yard coal-seam at Ashington colliery was worked on the longwall system, by means of a coal-cutter and a conveyor (Plate XVIII.).

The Yard seam contains 3 feet of coal, with about 3 inches of dark, soft seggar below it, and then about 12 inches of coarse fire-clay, overlying 30 to 40 feet of post. The roof is blue metal or shale, with post-panels, to a height of 42 feet; and it is overlain by 30 feet of strong post: the total cover being about 190 feet.

The district, in which this method is practised, is situated about a mile from the shaft, and was formerly worked by the ordinary longwall system, with gateways, 30 feet wide and mothergates, 390 feet apart.

The motive power is compressed air carried through pipes, 6 inches and 4 inches in diameter, from the bottom of the shaft, and with a pressure of 45 pounds per square inch at the face. The Diamond coal-cutter makes a cut 4½ feet deep and 4½ inches high, in the fire-clay below the coal. This cutter is fitted with sledges, instead of running on rails.

The conveyor, 288 feet long, has been in use for about 4 months. The length of face filled to the conveyor is 273 feet (Figs. 1 and 2, Plate XVIII.).

The mothergate, D, 12 feet wide, is let quarterly to a set of 8 men who also take up the bottom-canch, 3½ feet thick, and stow all stones at the side of the mothergate, in the goaf behind the conveyor-face. The mothergate is driven about 75 feet in advance of the face, and two sets of rolleyway-rails are laid with through shunts every 30 feet, so that the sets of empty tubs can be conveniently dropped back under the end of the conveyor. The seam rises about 1 in 30 in the direction of the advance of the bordways-face. The roof of the mothergate is secured by

means of steel-girders (12 feet long, 5 inches deep and 4½ inches wide) placed 2 feet apart; and hardwood-chocks (20 inches long, 5 inches wide and 5 inches thick) are built at the goaf-side of the mothergate every 4 feet, to relieve the pressure on the coal on the opposite side, thus preserving the roof until a second face is brought up on that side. So far, this system has been quite successful, and it is hoped by this means to avoid taking down a second canch, until the second face had passed, and then the stones could be utilized for building the packwall on that side of the mothergate.

The price for driving the mothergate, in addition to the tonnage-price for the coal, is 24s. 6d. per yard. This price is rather high; but it is due to the difficulty of stowing the stones as, owing to one face only being at work, they are all used on one side of the mothergate, and are cast as far as 40 feet from the brow of the canch.

The operations at the conveyor-face may be divided into three distinct classes of work carried out by:—(*a*) Coal-cutter machine-men and cleaners; (*b*) conveyor-men, who shift the conveyor, and draw and reset the timber; and (*c*) fillers.

Four machine-men and 3 cleaners have taken the face at £1 18s. 6d. per cut: all kirvings being thrown over the conveyor into the goaf. Two machine-men go to work at 1 a.m., one driving the engine and the other setting the guide-timber in front. The second shift goes in at 8 a.m., relieving their marrows at the face. One cleaner comes in at 4 a.m., and the remaining two at 7 a.m. The coal-cutter generally finishes its cut about 2 p.m.

The man in front of the engine sets a plank every 4 feet along the face and at right angles to it, with one prop, B^1, under it. This prop is placed 3¾ feet from the coal-side, and serves as a guide-prop for the coal-cutter. A pipe, 2½ inches in diameter, is laid along the face, with valves and union-couplings at intervals for connecting a length of armoured hose to the coal-cutter. At the end of the mothergate, this pipe is connected to the main air-pipes by means of a piece of flexible hose, 30 feet long, extra pipes being added to the main air-pipes, as required. The pipe along the face is attached to the framework of the conveyor, and is moved forward with it. The conveyor-engine is also supplied with air from this pipe.

The 7 conveyor-men shift the conveyor forward daily, and draw all timber from the goaf. They are paid by the piece at the rate of £1 18s. 6d. per cut. They go to work at 9 a.m., and, all going well, easily finish their work in 8 hours. The details of their work will be readily understood by reference to Fig. 4 (Plate XVIII.). A, B and C represent three rows of props under the old planks; and A^1, B^1 and C^1 represent three rows of props under the new planks. When the conveyor-men commence work, the coal-cutter is generally advanced about 150 feet along the face, and the new row of planks is in position, but with only a middle prop, B^1, under each plank, as shewn at P, near the coal-cutter; and, as soon as the machine is clear, one man starts to put in props at C^1 next to the coal, as shewn at Q. Unless this is done, the roof is found to shell off at the break. Two men then commence advancing the conveyor against the front row of props, C, by means of Hadfield prop-drawers and setting the back row of props, A^1, under the new planks. The planks are 6½ feet long, and when the conveyor is placed close to the front row of props, C, it is just possible to set the back row of props, A^1. The conveyor is shewn in this position at R. Two men then draw the front row of props, C (the end-props of the old planks); the guide-props, B^1; and gradually pull over the conveyor into position, as shewn at S. The remaining two men reset the guide-props, B^1, and then commence drawing the old planks and the props, A and B, as shewn at T. Prop-drawers are freely used, and every prop and plank is got out. The props are 3 feet long and 4½ inches in diameter. The planks are 6½ feet long, 5 inches wide and 2½ inches thick. Fig. 2 (Plate XVIII.) shows the face, and the conveyor in position, 18 inches from the coal, ready for the fillers after the conveyor-men have finished.

The filling is let quarterly by contract, at a price per ton, to 12 hewers, who fire the necessary shots. About one shot, E, every 20 feet along the face, is found to be sufficient. The price includes payment for filling the coals into the conveyor, and setting all temporary timber requisite for safety. One man remains at the engine-end of the conveyor to token the tubs, and to assist in passing them through. All filling is done in the night-shift, and all the fillers go to work at 7 p.m., with the exception of two, who go in at 3 p.m., to drill holes and

fire the shots. The hours and rules of ordinary hewers apply to this class of workmen. The face, at present, yields 13 scores of tubs each holding 9 cwts. or 116 tons per cut, and it is all filled in one shift. Fig. 3 (Plate XVIII.) shows the face broken down and being filled away.

In addition to one of the fillers, an engineman is placed in charge of the conveyor. This man is a trained mechanic; he goes to work 2 hours before the fillers, and sees that the conveyor is in working order. He also lays the additional pipes required for the main air-pipes, and does any necessary repairs to the coal-cutter.

TABLE III.—AVERAGE RATE OF COAL-FILLING.

Time.	Coals Filled.		Coals Filled. Rate per Hour.		Time	Coals Filled.		Coals Filled. Rate per Hour.	
P.M.	Scores.	Tubs.	Scores.	Tubs.	P.M.	Scores.	Tubs.	Scores.	Tubs.
7·00*	...		...		11·00	8	16	3	1
7·40†	...		...		12·00‡	10	0	1	4
8·00	0	10	1	10	A.M.				
8·40	1	14	1	16	1·00	11	15	1	15
9·00	2	16	3	6	2·00§	13	0	1	5
10·00	5	15	2	19					

* Fillers go down the pit. † Conveyor starts running. ‡ Bait or mealtime. § Work ceases.

Table III. shews the average rate of filling coals during a shift. During 2½ hours, the rate of coal-filling exceeds 3 scores per hour, after which the rate of filling drops very quickly, owing to the fillers beginning to square back the face for the passage of the coal-cutter on the following day.

The barrier-place, F, is let to a set of 8 hewers, who also form the stable, G (12 feet of side-coal), at the mothergate-end of the face. The barrier-place, 18 feet wide, is kept a cut in advance of the face. The hewers also take down the top-stone, 4 feet thick and 6 feet wide, and pack the side of the place behind the face. This barrier-place is kept open as a second outlet, in case of a fall in the face, and all timber is brought to this end and distributed along the face by means of the conveyor (Figs. 1 and 2, Plate XVIII.).

Amongst the general advantages of the conveyor-system may be mentioned:—(1) The increased output from a given area of workings. (2) The abolition of putting, and consequent reduction in the number of ponies: 4 ponies being saved on this face. (3) The reduction in the cost of stone-work; but this is counterbalanced by the cost of shifting forward the conveyor. (4) The increased output per man employed: 3 tons per man per shift

as against $2\frac{3}{4}$ tons by the ordinary system. (5) The increased percentage of round coal: 75 per cent. when passed over a screen with a $\frac{7}{8}$ inch mesh, as against 70 per cent. by ordinary filling after the coal-cutter: the increased number of large pieces being very noticeable. (6) The reduced cost of deputy-work: practically 50 per cent.

TABLE IV.—SHEWING THE DAILY TIMES OF COMMENCING EACH CLASS OF WORK.

Times.	Class of Work.
1 a.m.	First shift of coal-cutter machine-men.
4 a.m.	One cleaner, and hewers to make a stable at the mothergate.
7 a.m.	Two cleaners, and hewers to take in the face-canches in the mothergate and in the barrier-place.
8 a.m.	Second shift of coal-cutter machine-men.
9 a.m.	Conveyor-men.
10 a.m.	Second shift of hewers for the stable at the end of the mothergate.
3 p.m.	Shot-firers.
4 p.m.	Hewers for the mothergate and the barrier-place.
7 p.m.	Fillers.
10 p.m.	Hewers for the mothergate and the barrier-place.

Amongst, what may be termed, the disadvantages may be mentioned:—(1) An increased stock of tubs is necessary, as during the time that the fillers are filling at the rate of 3 scores per hour, it is necessary that the fillers should be, as far as possible, independent of any stoppages on the rolleyways; for a stoppage, at this time, is found to prevent the face from being cleared in one shift. (2) Increased supervision, as, owing to the different classes of workmen following each other so closely, and being dependent on each other, a stoppage throws the method of working out of gear. (3) The cost of timber at the face is about one-third more than with the ordinary method of working, and the enhanced cost is due to the fact that stouter props, $4\frac{1}{2}$ inches in diameter, are necessary to break off the roof, as no pack-walls are built in the goaf. Props are used, on an average, $2\frac{1}{2}$ times, and then they become too short and are sent out. There is only a low percentage of broken props. Planks are used, on an average, $3\frac{1}{2}$ times.

MR. FRED. C. KEIGHLEY (Uniontown, Pennsylvania, U.S.A.) wrote that he was of opinion that the use of coal-conveyors for filling at the working-face would be limited to the thinner seams of coal, and to seams of coal worked by the long-wall system of mining. Where a coal-seam was under 4 feet

tained information which would be most useful to Rand engineers.

Mr. PHILIP KIRKUP (Birtley) suggested that the scrapings from the coal-cutter should be cast direct into the goaf. The American mine-car described carried 30 cwts.; but in England, a much smaller tub was used. The depth of the under-cut and the dimensions of the road required for the large American truck would be very expensive to make and maintain.

Mr. H. RHODES asked whether the adoption of the large wagons had anything to do with the introduction of the conveyors. Thin seams, 3½ feet thick, were worked successfully and cheaply by small tubs in Great Britain, and he suggested that these would have answered as well as the conveyor.

Mr. W. C. BLACKETT said that experience in this country shewed that the quantity of coal got out by the conveyor was much greater than that by any form of small tub. The tubs were not supplied to the men without trouble and confusion, whereas the conveyor removed the coal as fast as it was filled.

The CHAIRMAN (Mr. J. S. Dixon) asked the depth from the surface, in the case of British collieries, where the system was in operation.

Mr. W. C. BLACKETT said that at Kimblesworth and Ashington collieries the depth from the surface was about 240 feet and 190 feet respectively, and at Herrington colliery about 1,000 feet.

The CHAIRMAN (Mr. J. S. Dixon) said he understood that the wastes were not packed. The face was supported by timber, and allowed to fall behind in the wastes. He noted that the gateways were 250 feet apart, but his difficulty had been to discover the source of the supply of material for packing.

Mr. W. C. BLACKETT said that the roads reserved for the passage of the tubs were packed by the material which was got out of the advance gateway. The rest of the face, along which the conveyor went, was not packed. There was no necessity for packing. In a thin seam, say, 4 or 5 feet thick, pack it as well as they might, the roof would still come down, say, 2 feet; and

if the roof could be lowered 2 feet in a seam 4 or 5 feet thick, it seemed to him that the roof could be lowered 2 feet in a seam 2 feet thick. At Ashington colliery, there was an example of a falling roof, and there was no packing.

The CHAIRMAN (Mr. J. S. Dixon) said that at depths of 1,000 or 2,000 feet the crush on the timbers was very great. With a depth of 180 feet, as at Vintondale colliery, a new set of circumstances arose altogether, and he asked whether the system had been working at great depths in this country. It was not a question of the conveyor only (that was a very interesting and instructive part of the paper), but whether the system of using no packing in longwall together with the conveyor-system was practicable.

Mr. W. C. BLACKETT remarked that, as he had said in the paper, "when proof has been adduced that a straight longwall-face of say 250 or 300 feet can be successfully maintained with a reasonable width of cantilever-supported roof-ledge and a reasonable quantity of timber, then the system is worth a trial."* At Herrington colliery, the seam was worked at a depth of 1,000 feet, the gradient was 1 in 9, and they had difficulties with the putting: the conveyor-system was introduced, and thereupon a considerable saving was effected of about 10d. a ton.

Mr. ROSLYN HOLIDAY (Featherstone Colliery) asked whether the apparatus was costly to repair. There would be falls or crushes sometimes, and the light iron supports for the troughs looked as if they would need complete renewal from time to time.

Mr. W. C. BLACKETT said that he had had conveyors at work for nearly 2 years, and had not experienced anything of that kind. Of course, if the roof fell and completely buried any portion of the machine, he imagined that they might never see it again; but, as a matter of everyday experience, they did not find that there was much wear-and-tear, and the repairs had been comparatively unimportant. The troughs were light, and easily knocked into shape again if they were damaged.

* *Trans. Inst. M. E.*, 1905, vol. xxix., page 451.

Mr. J. W. LIDDELL (Coventry) asked what was the nature of the seams worked by this method and whether the coal was coking, house or gas-coal. The percentage of slack made by the conveyors had not been mentioned in the paper; and this had an important bearing on its use in a tender or house-coal seam.

The CHAIRMAN (Mr. J. S. Dixon) said that the question would rather be what proportion of slack would be produced, as compared with the ordinary method of working.

Mr. W. C. BLACKETT said that some of the seams were tender, and might be called coking coals, and others were as hard as steam-coal. A steam-coal was worked at Ashington colliery, and the round coal (over $\frac{7}{8}$ inch mesh) had increased 5 per cent., the increased number of big pieces of coal being noticeable. At Kimblesworth and Charlaw collieries, more large coal was produced, partly on account of the conveyor-method of filling the coal, and partly because of the use of coal-cutters.

Mr. F. O. KIRKUP (Garesfield) remarked that the Low Main seam at Langley Park colliery produced a steam-coal, and with hand-labour the produce was 1·8 tons per man per shift; with the Diamond coal-cutter it was increased to 3·75 tons per shift; and the conveyor, in conjunction with the coal-cutter, produced about 8 tons per shift. At Garesfield colliery, the coal was a manufacturing or coking coal, and with hand-labour the produce was 2·8 tons per shift; and by adding the conveyor, the hewer having to cast the coal into it, it was increased to 4·1 tons per shift. At Langley Park colliery, the produce of round coal by hand-labour and blasting in a seam, 2 feet thick, was 32 per cent.; with a coal-cutter, the yield was 48 per cent. (casting across a gateway 36 feet wide). By adding the conveyor, the average yield was increased to about 72 per cent., and it had attained 78 per cent. for one fortnight.

Mr. C. C. LEACH asked whether the increased output was divided amongst the fillers, or whether it included the extra men who attended to the coal-cutters and conveyors.

Mr. F. O. KIRKUP replied that, taking all the hands employed, including the machine-men and the conveyor-chargemen, the output had increased from 1·8 to 3·1 tons per shift.

Mr. PHILIP KIRKUP asked, having regard to an accident happening whereby the conveyor was buried and lost, whether Mr. Blackett could state the cost of replacing the conveyor and the trough.

Mr. W. C. BLACKETT replied that the cost of renewing the troughs was very different from the cost of the complete conveyor, with driving motors, etc. He had only known one instance in the goaf where half-a-dozen lengths were lost, and it was then considered that the cost of recovering them would be greater than the cost of new ones.

The CHAIRMAN (Mr. J. S. Dixon) asked whether it was necessary in every instance to rip the floor, so as to afford head-room for the tubs. He supposed that a hard floor would prove an obstacle to the introduction of conveyors.

Mr. W. C. BLACKETT said that he had contemplated the use of an elevator at the end of the conveyor, in order to elevate the coal above the tubs; but, unless it could not be avoided, it was hardly desirable to do so. At Vintondale colliery, height was made in the bottom-stone in the same way as was done in this country. The trough was raised at the tail-end and the head-end (Fig. 11) in order that the chain might pass round the tumblers. At Kimblesworth colliery, the height was formerly made in the roof of the seam, 2½ feet thick; the roof was a bad one and much softer than the bottom, but, in order to use the conveyor, the height for the tubs was now made in the harder bottom-stone.

Mr. H. S. SMITH (Bath) said that he was working coal-seams, from 14 to 28 inches thick, intersected by numerous small faults, and he would be glad to know whether Mr. Blackett had had any experience in traversing the conveyor over faults, and with what result.

Mr. W. C. BLACKETT said that he had pointed out, at the beginning of his paper, that certain conditions were adverse to the use of a coal-cutting machine and the same conditions were also adverse to the use of a conveyor. These adverse conditions included places "where the roof or floor is bad, where there are numerous faults or dykes, or where the seams are highly

inclined."* With regard to a conveyor, highly inclined seams would not matter very much. In the case of troubles, it was desirable to leave as small a slack or hollow as possible; if the trouble was a large one, it was necessary to make special arrangements; and if it was a small one, the conveyor could be raised by means of temporary supports and kept as nearly level as was feasible. A trouble, with a throw of 2 feet, would not present any great difficulty.

Mr. H. S. SMITH said that the conveyor did not appear to be particularly applicable to a rising seam or a dipping seam; but the mine must be level, and there must be a good roof.

Mr. W. C. BLACKETT said that the conveyor could be applied to a rising seam or a falling seam, as well as a level one, provided that the fall was not too great for the motor driving the machinery.

Mr. H. R. HEWITT (H.M. Inspector of Mines, Derby) said that Mr. Blackett must be working a peculiar seam, if he was able to arrange to work it on the longwall system, without pack-walls. He understood that shots were fired when the conveyor was close to the face, and it seemed probable that damage might be caused to the conveyor. He had heard of a single endless rope being used along the main roads and cross-gateways, delivering empty tubs and picking up full ones, and travelling round the district as a single road. The system* abandoned by Mr. Ware in America appeared to have been a similar system carried along the working-face; and, owing to the peculiar condition of some working-places, it could not possibly meet with success in general practice.

Mr. W. C. BLACKETT said that the shots were fired to break up the coal, and not to get it down. The coal came down in blocks, too large to be placed upon the conveyor, and one of the features of the system was that, in breaking the coal, the hewer was not tempted to break it still further for the purpose of getting it into a tub a long way off. Large coal was obtained, because it was easier for the men to place it upon the conveyor.

* *Trans. Inst. M. E.*, 1905, vol. xxix., page 450.

† *Ibid.*, 1900, vol. xviii., page 351.

The system, mentioned by Mr. Hewitt, was abandoned at Vintondale colliery in order to adopt the more advantageous conveyor-system.

The CHAIRMAN (Mr. J. S. Dixon), in moving a vote of thanks to Messrs. W. C. Blackett and R. G. Ware for their interesting paper, said that the conveyor was one of the latest of the new departures in mining, and no doubt there was a great field before it, as coal-cutters were making rapid progress, especially in thin seams. He had no doubt that the members would study the paper and the discussion with great interest.

Mr. C. C. LEACH seconded the resolution, which was very cordially adopted.

Mr. C. C. Leach then took the chair.

Mr. THOMAS ADAMSON's paper on "Underground Horses at an Indian Colliery" was read as follows:—

UNDERGROUND HORSES AT AN INDIAN COLLIERY.

By THOMAS ADAMSON.

Following the paper by Mr. F. O. Solomon on "The Feeding of Horses, with Special Reference to Colliery Studs,"* and the discussion thereon, and that on "Underground Stables" by Mr. W. C. Blackett,† it may interest the members to have a few notes on the underground horses at the East Indian Railway collieries, Bengal, India.

Horses.—Horses were introduced into these mines in 1890 by Dr. Walter Saise, colliery-superintendent; and since then the number of horses and ponies has steadily increased, until now there are 140, of which 90 are in constant work, the rest being mares (kept mostly for breeding purposes) and foals under 4 years of age. Dr. Saise has given a great deal of personal attention to the breeding and feeding of the horses, and it is from the experience gained in the experiments conducted by him that the writer is able to compile the following notes.

The animals are, with the exception of three Burmese stallions, all country-bred and cross-bred, and in height range from 10 to 14½ hands. The Burmese ponies are sturdy animals, in build very like Shetland ponies. The Burmese stallions were imported for the purpose of improving the stock, as the country-bred ponies (compared with English ponies of the same height) are much lighter in build. The experiment in breeding, with Burmese stallions and country-bred mares, has been very successful, the stock raised being superior to the small country-bred animals. Bigger animals, country-bred, have been introduced of late, but no attempt to breed from these bigger ones has yet been made.

* *Trans. Inst. M. E.*, 1900, vol. xix., page 279.

† *Ibid.*, 1902, vol. xxiv., page 482.

For comparison with horses in British mines, the writer appends Table I., showing the heights and girth-measurements of Indian and Burmese horses: the girth being taken round the chest. Half the number of horses in work have been bred on the colliery.

TABLE I.—HEIGHTS AND GIRTH-MEASUREMENTS OF INDIAN AND BURMESE HORSES.

Class of Horses.	Averages of the Horses at Work. Heights. Hands.	Girths. Inches
Country bred	10 to 11	45
Do.	11 to 12	49
Do.	12 to 13	53
Do.	13 to 14	58
Do.	14¼	61
Burmese stallions	12½	55
Do.	13	59
Cross-bred from Burmese stallion and country-bred mares: 11 months old	10½	43
Cross-bred from Burmese stallion and country-bred mares: 30 months old	11¾	48

The young stock is allowed plenty of exercise, being allowed to run all over the Gujiadih estate. At night-time, the animals sleep in a large shed, and all lie together like a lot of dogs. They are not put to work until they are four years of age.

Feeding.—The rations have varied from time to time, according to the price of food-stuff, and according as experience has taught the management what is the best food for the stud.

Sometimes, the horses have been fed solely on gram (a pulse like the bean or pea); oats; maize or indian corn; a mixture of gram and oats; oats and maize; gram and maize; and gram, oats and maize. Wheaten bran, when cheap, is added; also unhusked rice, grown on the East Indian Railway colliery-farm, has been used. The food is crushed by passing it between iron rollers.

The food that has given the best results contained the following proportions:—28 per cent. of maize, 14 per cent. of gram, and 58 per cent. of oats, well mixed together.

A pony, from 10 to 12 hands high, is given 6 pounds of crushed food and 3 pounds of hay; and the bigger horses, 8 pounds of crushed food and 4 pounds of hay, daily. They are fed three times a day:—(1) In the morning before work; (2) inbye, during the shift; and (3) at the end of the shift.

The horses work about 8 hours per day, and as they are in very good condition, the diet may be said to be satisfactory.

Cost of Horse-keep.—Gram, January, 1905, costs £3 17s. 1½d. per ton; oats, £5 1s. 3d. per ton; and maize, £3 8s. per ton.

Grass is cut and brought in by the villagers and sold at 2d. (2 annas) per maund or 4s. 6½d. per ton. The grass is dried and stacked, and used as required. The grass in drying loses 80 per cent. of its weight, so that when it is ready for use, as hay, its cost is £1 2s. 8½d. per ton. Grass can only be procured in the rainy season (July 1st to October 31st), and enough is stacked then for use through the year.

Seven varieties of grass are used as fodder at the East Indian Railway collieries, as follows:—

(1) Dub or doob (*Cynodon dactylon*) grows all the year round. It is a common fodder-grass, and has a creeping stem which throws out roots.

(2) Dub-dul (*Panicum stagninum*) grows in tanks in cold and hot weather. Horses eat it without relish, but cattle will not eat it. It looks like coarse doob, as it has a long creeping (floating) stem.

(3) Makra ghas (*Eleusine ægyptiaca*), called suntubokoé by the Santals, grows in Indian corn baris. It consists of isolated plants, with erect leaves and stems. It is very like mandua in appearance. The Santals say that it was the food first given to the first men who appeared on earth. Women bring in great bundles in August, September and October.

(4) Sama, a road-side grass (*Panicum colonum*), only leaves and erect stems, each plant separate, grows well in the rains, and horses eat it with great zest. It is practically the meadow-grass of the rains.

(5) Churant (*Andropogum*), the seeds stick to one's clothes. It is a cold-weather grass.

(6) Phulhar (*Eragrostis tenella*), called ic koé by the Santals, is a feathery grass, with large panicles of the everlasting grass style. It is a cold-weather grass.

(7) Marndi-grass (*Ischaenum rugosum*) is so like rice as to be undistinguishable until it flowers. It is available in December.

All these grasses are bought for the horses, and in hot weather

dub-dul is chiefly eaten. In cold weather, dub-dul, marndi, churant and phulhar; and in the rainy season, sama, makra and dub form their food.

The cost of feeding the stud for the years 1902 and 1903 was 6s. 7d. (4 rupees 15 annas) per animal per month. As 36 per cent. of the stud are mares and foals under 4 years of age, not at work, they do not receive as much crushed food as those at work: the actual cost of feeding the animals at work, amounted to 8s. 3d. (6 rupees 12 annas) per animal per month.

The horses work six days a week, and are given a rest on Sundays. Where there are adits or inclined roads into the mines, the horses are brought out every Saturday night, and taken back again on Monday morning: more than half the horses enjoy this boon.

Shoeing.—Ponies under 12 hands are not shod. The rest are shod, which is done by contract costing 1s. 4d. (1 rupee) per horse per month.

Drivers.—The drivers are mostly strong young men, 18 years of age and over. They are men who understand horses, and are a sort of horsekeeper and driver combined, as they feed and groom their horses as well as drive them. They work 10 hours a day and are paid 4d. (4 annas) per day, and, compared with that of the coolie or labourer of 2½d. per day, this is considered a good wage.

Stables.—The stables are built in several places in the mine; from 2 to 12 horses being stabled together. Plenty of room is given to each horse, and they are separated by wooden partitions. The stables are 8 to 10 feet in height, the seam being 16 to 23 feet thick. The floors are made of glazed tiles, and the mangers of brickwork lined with cement (Plate XIX.). Water-troughs are provided in convenient places, in or near the stables.

The stables are whitewashed from time to time. The ventilation is arranged so that fresh air passes direct from the intake-airway, through the stables, into the main return-airway.

Labour.—Before horses were introduced into these mines, the tubs were taken from the working-face to the shaft by trammers, mostly women. Horses were introduced to take the

place of the women, as it was expected that legislation would interfere with female labour underground. At first little, or no advantage was gained, as the trammers would still see their tubs taken to the shaft and put into the cage, for they were afraid that their tickets or tokens would be changed and that their tubs would be booked to another person. This is all altered now, the coal-cutter no longer leaves his working-place during the shift, and women have to some extent been replaced by horses.

Legislation has not yet prohibited female labour in Indian mines. But the prohibition must come sooner or later, and when it does, the East Indian Railway collieries will be prepared for it.

Horse-sickness.—Sickness is very rare amongst colliery-horses. Three or four horses have died of tetanus. No veterinary surgeon is kept, and the horses' little ailments are attended to by their drivers, and by the colliery-officials.

Mr. J. P. Kirkup (Burnhope) wrote that Mr. Adamson's paper pointed to a distinct advance in Indian mining, although it was at times necessary to consider carefully whether the introduction even of mechanical power was an economy, as compared with the low-priced labour available. The class of horse available in India was much inferior to that used in European mines, and the use of horses would probably be restricted to light tramming work. It would have added to the interest of Mr. Adamson's paper, if he had given the comparative cost of horse-work with that of hand-labour. It appeared to be a somewhat extravagant system, so far as it had been developed. The employment of a highly paid *syce** with each animal would correspond with the employment in this country of a horsekeeper with each, and was pandering too much to the native idea of one man to each horse. The food of the horse was also very largely that of his keeper; and, without very careful supervision, the horse-owner would find that the keeper and his family were fed at his expense, together with the animal. The only reliable check upon this pilfering was the very disgusting one of fouling the horse-food with urine.

* *Syce* is the Indian equivalent of a groom or horsekeeper.

With reference to the anticipated prohibition of female labour underground, he (Mr. Kirkup) trusted that the Government of India would not act in too sudden a manner, as it would cause much distress to a large body of workers, who, owing to the extreme simplicity of their home-life, could not be employed in domestic duties, and would not for a time, be absorbed in other industrial occupations.

The CHAIRMAN (Mr. C. C. Leach), in moving a vote of thanks to Mr. Adamson, said that his interesting paper gave an account of the introduction of horses into Indian mines, where a very great deal of care seemed to be taken of them. No doubt, in the collieries at home they were taking more care of the pit-ponies than formerly. They could not compare the cost of these horses with our own, as the feeding and other conditions were so different.

Mr. M. WALTON BROWN seconded the resolution, which was cordially adopted.

DISCUSSION OF MR. J. CRESSWELL-ROSCAMP'S PAPER ON "AN IMPROVED APPARATUS FOR LAYING DUST IN COAL-MINES."*

Mr. W. WALKER (H.M. Inspector of Mines, Doncaster) wrote that he had no doubt that the method described, in conjunction with measures to prevent the making and accumulation of coal-dust in mines, would do much good. The most efficient means of watering dust, in his opinion, was by stand- and hose-pipes on the haulage and travelling roads. It was quite the reverse of his experience that the result of water being applied under pressure to thoroughly dry dust, was that it ran off the finer dust in the form of spherules and thus became a means of raising rather than laying dust, if the watering was done regularly and judiciously. He (Mr. Walker) could quote many instances where hose-pipes were used, with water brought in pipes from the shaft-tubbing under considerable pressure, where the result of the watering was entirely satisfactory and more lasting than the results obtained by water-sprays. There could be no doubt that in some

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 578.

seams the application of water had a prejudicial effect on the floor and sides of the roads, but not to such an extent as was often urged by those whose duty it was to see that the coal-dust danger was reduced to a minimum. It had often occurred to him (Mr. Walker) that some other liquid might be used than water to overcome this difficulty, and also to obtain more lasting results in the laying of dust than were obtained at present. Mr. A. A. Atkinson's suggestion that a Committee of the Institution should be appointed to investigate thoroughly, experiment on, and report on, this admittedly important question was an excellent one. There could be no doubt that the results of such an investigation would be of great benefit to the members, and he hoped that the suggestion would be favourably considered by the Council.

Mr. GEORGE FARMER (Mexboro') considered that the question of watering roadways in coal-mines for the treatment of coal-dust was one which did, and would, engage the attention of mining engineers, and more especially so, as workings become deeper and consequently dry and hot. It was very questionable, however, whether a spray of water would give the desired result. Without doubt, the apparatus described by Mr. Cresswell-Roscamp was one of the best on the market, and every credit was due to him for his attention to the subject; but it was very doubtful whether the whole of the available dust, on roof, floor and sides, would be permeated to such an extent as to render it absolutely damp, and, it might be said, safe. Water effectually damped only the surface of the dust, unless it was very frequently used; and, with a strong ventilating current in a naturally hot and dry mine, this watering was very soon rendered ineffectual. If roadways were very dusty, it was very questionable whether a spray would be sufficiently heavy to be really effectual in damping the whole of the dust. More often than not, the upper portion of the dust would be wetted, and would form a crust covering over the finest and most dangerous kind of dust. This, in his (Mr. Farmer's) opinion, was something in the order of a lurking danger behind a sham prevention. He would suggest, since danger must be reduced in a very effectual manner to do any real good, that the bulk of the dust should be filled into tubs and sent to the surface before watering took place. In fact, portions of a roadway might be perfectly cleaned, roof, floor and

sides, by sweeping and removing the dust. The portions might each be from 300 to 500 feet long, the position and number of such portions depending on the length of the intake and return airways. Such portions could be kept always scrupulously free from dust by brushing or otherwise, and might be lime-washed. It was not probable, in the absence of an explosive quantity of fire-damp in the air, that the flame of an explosion would travel over a length of 300 to 500 feet without a supply of combustible material, such as coal-dust. One man would probably be able to keep four or five such lengths of gallery scrupulously clean, after they had been once well swept. It was also very probable that water-spraying would be more effectual in damping all the dust, and thus reducing the danger to a minimum. Even in working-faces, or places where shot-firing was used, the thickest dust must be removed, so as to render the watering effectual; unless the water was poured on copiously, which would induce danger from falls of roof and side. Copious watering had, in some cases, been blamed for the production and spread of ankylostomiasis; but it was clearly evident that the dust must be removed in some way. Thorough cleansing, such as that above described, followed by a continual damping, seemed to be the most efficient in all cases. In addition, the mine would be healthier, owing to the decrease in the volume of dust, the injurious effect of water on the roof and sides would not be so serious, and the dust could be used as fuel.

Mr. J. B. Atkinson (H.M. Inspector of Mines, Newcastle-upon-Tyne) wrote that the paper described a sprayer, which he had seen in action and it did undoubtedly spread a fine spray. Mr. Roscamp described the apparatus, but the information given as to the results was not satisfactory. Table I. was difficult to understand; Table II. recorded no readings of the wet- and dry-bulb thermometers; while Table III. gave the quantity of water distributed, but afforded no information as to the effect.

The question of preventing accumulations of dry coal-dust in mines deserved serious attention, and as collieries were yearly becoming deeper, drier, and more extensive, it would increase in importance. He was convinced that coal-dust could be satisfactorily dealt with. At a large and naturally dusty colliery in Durham, he had found some of the main haulage-roads practi-

seams the application of water had a prejudicial effect on the
and sides of the roads, but not to such an extent as was o
by those whose duty it was to see that the coal-dust
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...tically. He (Mr. Roscamp) differed from Mr. ... opinion that the clearing-away of the thickest ...st and the brushing of the roadways would ...ct. In his (Mr. Roscamp's) opinion, this ...real danger, which arose from the finest ... to the roof and sides, and collecting in ...adway-timber, these particles could ... by adding moisture to them; and ...pted than by causing an atmo- ...ith its temperature reduced as ...ways? In his opinion, the ...-dust from the roadways, ...ions, was starting alto- ...oval would only take ...Whereas, by the use ...e when clouds of

...re taken every ...ad come under the ...when the readings had ...y. Thus, the table records ...e sprayer and the lapse of time ...ppeared to be affected.

...rmometrical readings were taken at ...ustrate the fact that the air of the mine ... by the use of the water-spray.

...ad been made to the sanitary effects of water- also in regard to the possibility of some advantage ... by the use of disinfectant and dust-binding fluids in ... of ordinary water. He (Mr. Roscamp) had recently made several experiments with the following fluids:—(1) Ankylocide, (2) pyne-oiline, and (3) common rock-salt. Ankylocide and pyne-oiline are solutions of an oleaginous nature, the former is said to be a strong disinfectant, while the latter contains a high percentage of pitch. A dry and untreated length of roadway was selected for each of the tests, and careful notice was taken to observe the length of time that each solution kept the roadway moist. The results of these experiments are recorded in Table IV.

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 579.

† *Ibid.*, page 580.

cally free from coal-dust, more by attention to details than by any heroic measures.

Some of the points to be considered might be stated as follows:—(1) Thermometrical and hygrometrical conditions of mines likely to cause coal-dust to accumulate. (2) Means to prevent the formation of dust-deposits in the working of coal. (3) In its leading, especially on engine haulage-roads. (4) In the prevention of coal-dust (from the screens on the surface) from descending the downcast shaft. (5) The application of water or removal of the dust. (6) The investigation of the minimum speed of air-current that would transport dust. He was also of opinion that the question seemed to be a proper one for investigation by means of a committee appointed by the Council.

Mr. J. Cresswell-Roscamp (Ravensworth Colliery) wrote that Mr. W. Walker mentioned the wellknown system of laying pipes along the wagonways and travelling-roads: the requisite pressure of water being obtained from the shaft-tubbing and rising-main. This was certainly one efficient method of dealing with coal-dust, but he objected to the statement that it was the most efficient means. The results obtained from this method would be identical with those afforded by the water-sprayer described in his paper, if sufficient pressure were obtained and a nozzle of sufficient fineness used: that was, a spray of extreme fineness, resembling steam or vapour, would reach to roof, timber, floor and sides. It would also moisten the ingoing current of air, and so lower the temperature of the workings and prevent the finest portions of dust from being formed. The similarity in results was all that could be said for the two systems. The first cost of the sprayer was the total and only cost; it was filled with water at the shaft-bottom and afterwards sent inbye and outbye as an ordinary tub; the working was automatic, and required no attention beyond cleaning; and the cost of upkeep was small. Whereas, in the case of pipes, the first cost would be enormous; the cost of upkeep heavy; and the working-cost, for a pit drawing 1,000 tons per day, would be at least two men's wages daily.

Mr. Farmer stated that it was very questionable whether a spray of water would give the result desired, namely, the damping of coal-dust. Whether this system attained the desired result depended entirely upon the spraying being carried out regularly

and systematically. He (Mr. Roscamp) differed from Mr. Farmer in the opinion that the clearing-away of the thickest portion of the dust and the brushing of the roadways would have the desired effect. In his (Mr. Roscamp's) opinion, this dust did not offer the real danger, which arose from the finest particles of dust, adhering to the roof and sides, and collecting in layers on the supporting roadway-timber, these particles could only be rendered non-explosive by adding moisture to them; and what better means could be adopted than by causing an atmosphere, laden with moisture and with its temperature reduced as low as possible, to traverse the roadways? In his opinion, the clearing of thick accumulations of coal-dust from the roadways, as an effectual preventive to dust-explosions, was starting altogether at the wrong end; because the removal would only take place after the tubs had finished running. Whereas, by the use of water-sprays, the remedy was used at the time when clouds of dust were raised by the passing tubs.

In Table I.,* the hygrometrical readings were taken every ¼ hour, from before the time when the air had come under the influence of the water-sprayer to a time when the readings had assumed the same percentage of humidity. Thus, the table records the difference due to the effect of the sprayer and the lapse of time during which the atmosphere appeared to be affected.

In Table II.,† the thermometrical readings were taken at two points, so as to illustrate the fact that the air of the mine was actually cooled by the use of the water-spray.

Reference had been made to the sanitary effects of water-sprays, and also in regard to the possibility of some advantage accruing by the use of disinfectant and dust-binding fluids in place of ordinary water. He (Mr. Roscamp) had recently made several experiments with the following fluids:—(1) Ankylocide, (2) pyne-oiline, and (3) common rock-salt. Ankylocide and pyne-oiline are solutions of an oleaginous nature, the former is said to be a strong disinfectant, while the latter contains a high percentage of pitch. A dry and untreated length of roadway was selected for each of the tests, and careful notice was taken to observe the length of time that each solution kept the roadway moist. The results of these experiments are recorded in Table IV.

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 579.

† *Ibid.*, page 580.

TABLE IV.—EXPERIMENTS WITH DISINFECTANT AND DUST-BINDING SOLUTIONS.

Nature of Solution.				Duration of Effect.
	Per cent.		Per cent.	Hours.
Ankylocide ...	... 30	Water... ...	... 70	49
,, ...	... 20	,, ...	... 80	34
,, ...	... 10	,, ...	... 90	19
,, ...	... 5	,, ...	... 95	11
Nil	... 0	,, ...	... 100	5
Pyne-oiline ...	... 10	,, ...	... 90	17
Rock-salt* ...	... 2·8	,, ...	... 97·2	7

* 28 pounds of rock-salt to 100 gallons of water.

The tub employed in making these tests was 4 feet long, 2 feet 10 inches wide and 1 foot 10 inches deep; and it contained 120 gallons of water: a quantity sufficient to dampen a length of about 6,000 feet of roadways. The costs of these preparations are as follow:—Ankylocide, £18 10s. per ton; and pyne-oiline, £10 per ton. One ton of either preparation contains 250 gallons.

Mr. M. WALTON BROWN wrote that an approximation to the duration of the effects of 120 gallons of dust-laying liquids in coal-mines could be obtained by the use of the following formula:—$D = a + 1{\cdot}5b$: D, being the duration of the effect in hours; a, a constant varying with the efficiency of the fluid; and b, the percentage of the fluid dissolved in water. The following values of the constant, a, had been determined from Mr. Roscamp's experiments (Table IV.):—Ankylocide, 4 hours; pyne-oiline, 2 hours; and water, 5 hours. One hundred and twenty gallons of a solution containing 6 per cent. of ankylocide or 7⅓ per cent. of pyne-oiline would allay the dust in about 6,000 feet of roadways in a coal-mine for 13 hours, the relative costs per 120 gallons of these solutions being about 10s. 8d. and 7s. 0½d. respectively. The preceding formula indicated that (1) there would be considerable economy in applying a solution containing a lower percentage of the dust-allaying fluid, twice or thrice during the suggested period of 13 hours; and that (2) water alone, frequently applied was more efficient and much less costly than either of the fluids employed in Mr. Roscamp's experiments.

Dr. G. A. F. MOLENGRAAFF'S paper on "The Cullinan Diamond" was read as follows:—

THE CULLINAN DIAMOND.

By Dr. G. A. F. MOLENGRAAFF.

The big diamond is a portion of a much larger stone, the original form of which can only be roughly guessed at. Four pieces of this original stone have been broken off along cleavage-planes, which we know to have the position of octahedral planes. Each of these fragments must have been of considerable size. Consequently, the stone itself shows only a portion of its original natural surface (called "nyf" in the diamond-cutters' jargon), the greater portion being formed by these four flat cleavage-planes. The remaining part of the surface shows one octahedral face and a curved irregular surface roughly corresponding to six faces of the dodecahedron, while one very irregular face of the hexahedron is indicated by quadrilateral impressions which are characteristic of these faces in minerals, such as the diamond, which possesses the octahedral mode of growth.

The stone is a single crystal, no twinning-planes or twinning-lamellæ being present. It is quite colourless, its perfect transparency being best compared to that of pure ice or of the variety of silica known as hyalite. There are a few grains (inclusions), and also some flaws, or internal cleavage-planes—"glessen," as the diamond-cutters call them—in it, but their position is such that they do not detract from the value of the stone as a gem. It is certainly the purest of all the very big stones known.

The question is raised whether there is any likelihood of finding the fragments which have been detached from this stone by cleavage. It is of course, possible, but nobody can say whether or where they will be found in the mine. Diamonds are formed at very great depths from carbon dissolved in the molten basic igneous rock (blue ground), from which, under the conditions of enormous pressure and very high temperature prevailing at these depths, the carbon crystallizes out in the

form of diamond. During the period of eruption, the diamonds were carried to the surface with great force, and the excessive friction which must have existed in the magma during ejection through the crater-pipe caused the fragments to be cleaved from the original stone. They may have been blown out during the eruption, or they may still be in the volcanic chimney (diamond-pipe) and may be unearthed some other day in the long and promising life of this big mine.

FIG. 1.—THE CULLINAN DIAMOND : SHEWING ONE OF THE CLEAVAGE-PLANES. NATURAL SIZE, FROM A PHOTOGRAPH BY MR. MELVILL.

The Cullinan diamond was found in the Premier mine, near Pretoria, by Mr. Wells, surface-manager, in the yellow ground about 18 feet from the surface, on January 25th, 1905.

The weight of the stone is 3,024$\frac{3}{4}$ carats or about 1·7 pounds troy, and the dimensions are about 4 inches by 2$\frac{1}{2}$ inches by 1$\frac{1}{4}$ inches.

The CHAIRMAN (Mr. C. C. Leach), in moving a vote of thanks to Dr. Molengraaff for his interesting description of the Cullinan diamond, remarked that it was one of the largest diamonds in the world.

Mr. W. SAINT seconded the resolution, which was cordially approved.

Mr. A. R. SAWYER's paper on "The Geology of Chunies Poort, Transvaal," was read as follows:—

THE GEOLOGY OF CHUNIES POORT, TRANSVAAL.

By A. R. SAWYER.

Chunies Poort is situated about 22 miles south of Pietersburg, Zoutpansberg, Transvaal (Fig. 1, Plate XX.). Dr. G. A. F. Molengraaff included it in his geological map and refers to it in his paper on the geology of the Transvaal.*

Geology.—The formations occurring at Chunies Poort are the Black Reef series, and the Dolomite series, which lies conformably upon it (Fig. 2, Plate XX.). The Black Reef series attains its greatest thickness in the Transvaal at Chunies Poort, where it is about 1,200 feet thick. It forms there its highest escarpment, attaining a height of about 2,500 feet above the level of the country. It has a fairly regular dip-slope, as shown in the section (Fig. 3, Plate XX.), of about 26 degrees south. It rests directly upon the Basement Granite. Three important quartzite-beds occur in this series, each one of which forms a prominent escarpment; the upper one continuously, and the other two in part.

The following is a rough section of the rocks forming the Black Reef series at Chunies Poort, in order of superposition:—

	Feet.
Upper Quartzite, consisting of white, grey and dark bluish-black and banded beds. The banded beds are very characteristic, the bands which vary from ½ inch to 12 inches, are bluish-black in white quartzite. The bands are occasionally so arranged as nearly to resemble a a piano key-board. This bed forms a prominent outcrop, and the upper layers contain some banket-beds, which can be seen near the bottom of the dip-slope and in the river-bed, associated with blue quartzite ...	200 to 300
Quartzitic sandstone, dark yellowish-grey and laminated	300
Ferruginous sugary sandstone	2
Central Quartzite, white, glassy in part. It is banded, in part, with thin bands; and shows, in places, much false bedding	200

* "Géologie de la République Sud-Africaine du Transvaal," *Bulletin de la Société Géologique de France*, 1901, series 4, vol. i., page 31; and *Geology of the Transvaal*, 1904.

Feet.

West of Chunies Poort, at the escarpment, this section contains, near the bottom, breccia and some conglomerate resting in part on, and in part apparently interbedded with, diabase and diabase-schist, as follows:—Breccia; diabase-schist, 6 feet; breccia, 6 feet; conglomerate, 1 foot; diabase-schist, 2 feet; and diabase. The breccia contains angular pieces of quartzitic sandstone, shale and quartz, up to 18 inches long. The conglomerate is partly cupriferous. The diabase and diabase-schist contain some malachite and gold; and ferric sulphate ($Fe_2 3SO_4$), with a taste resembling that of alum, for which it might therefore be mistaken from a casual examination, occurs amongst these rocks as a sublimate.

On the east side of Chunies Poort, the writer could not find any trace of breccia, conglomerate, diabase-schist, or diabase. A few feet of highly argillaceous sandstone occur near the base of the section. It would therefore appear that the presence of these rocks on the western side of Chunies Poort is local. Prospecting seems to have been undertaken there formerly, judging by the presence of old workings.

	Feet.
Yellow sandstone	
Black shale, 2 feet	
Yellow sandstone, thick	
White quartzitic sandstone	about 110
Argillaceous laminated sandstone	
Yellow sandstone	
Quartzite, very fine-grained, with bands of black shale ...	
Sandstone, white, ochreous, ripple-marked	
Quartzite, with bands of shale	
Yellow ferruginous sandstone, 2 feet	90
Quartzite, with bands of shale	
Quartzite, fine-grained, grey, with shale-bands and laminæ, more laminated	
Grey shale, 1 inch	
Quartzite, showing false bedding	
Quartzite, dark greyish-green	160
Quartzite white, showing false bedding	
Lower Quartzite, consisting of:	
Light-grey quartzite, banded with dark irregular bands	
Light-grey quartzite and quartzitic sandstone	
Brown quartzite	
Yellow sandstone, soft and weathered, causing the quartzites above to hang over, 1 foot	90
Harder sandstone	
Brown quartzite	
Bluish quartzite	
Greyish-green quartzite	
Basement Granite	...

The overlying Dolomite series consists at Chunies Poort of the usual dark-blue dolomite, with bands and concretions of chert; a few thin bands of black shale, sandstone, and the usual quartzite occur interbedded with it.

A notable feature at Chunies Poort is, however, the occurrence of beds of breccia and banded quartzite interbedded in the dolomite. The thick banded quartzite-bed (Fig. 3, Plate XX.) consists mostly of black and yellow bands which run very regularly. Some grey and reddish bands occur, as also thin bands of hæmatite. The black bands vary from $\frac{1}{16}$ inch to a few inches in thickness. This quartzite-bed is about 200 feet thick, and shows considerable contortion and breaks in places, especially at the south-eastern corner of Rooiboklaagte farm and in the bed of the Chunies river (Fig. 2, Plate XX.). These contortions and breaks are no doubt due to pressure, as in the banded quartzites of the Lower Witwatersrand beds, which show similar contortions and breaks, and to some extent resemble this bed. Dr. G. A. F. Molengraaff noticed banded quartzites in the Pretoria series, which lies unconformably on the Dolomite series, but banded quartzites have not been notified previously in the Dolomite series.

A thick deposit of secondary breccia, containing the constituents of the banded quartzite as pebbles, lies on the dip-slope of the banded quartzite, which, in conformity with all the other beds of the Dolomite series (except where thrown up as described hereinafter), dips here to the south. The pebbles are frequently long and angular, the longer axis lying parallel to the dip-slope: some being 10 inches long and 3 inches thick.

Manganese-deposits, occurring so frequently in this formation elsewhere, appear to be scarce here. One deposit occurs on a farm adjoining Doornkloof and Blaauwbank farms to the south. This manganese repository, which appears to be pockety, lies between a bed of breccia which forms its hanging-wall, and a bed of dolomite, which forms its foot-wall. It has been worked, some time back, as shown by the occurrence of large trees in some of the old workings. Three of the breccia-beds, shown in Figs. 3 and 4 (Plate XX.) consist of various-sized angular pieces of white quartz, transparent at the edges, embedded in a siliceous matrix. The dolomite is, in part, coloured red in the vicinity of the manganese.

Diabase-sheets and dykes occur, as usual, in this formation. These are of great importance here, as numerous quartz-reefs, some of which have been exposed by trenching and shaft-sinking, occur in them, and apparently, so far as can be seen on the surface, in them alone.

Some old copper workings occur farther south on the Storm farm (Fig. 2, Plate XX.). A graphitic layer, containing malachite and native copper, has been partly worked out to a depth of 24 feet. Native copper and malachite occur, in some abundance, in the harder dolomite-walls. The width of the workings is 13 feet. The occurrence of native copper in the Dolomite series has not, so far as the writer is aware, been previously recorded. A dolomite-breccia occurs in their vicinity, the dolomite containing numerous pieces of black shale and some chert-nodules; together with a pink dolomite and a bed of red clay-rock (Fig. 3, Plate XX.).

A very characteristic series of beds of dolomite and chert, a few feet thick, containing numerous ripple and concretionary markings, bearing great resemblance to *Sigillaria*, occur on the Chunies Poort West farm (Fig. 3, Plate XX. and Fig. 8, Plate XX.). Through a dyke-intrusion at its south-western corner, these beds have been tilted and thus crop out twice, as shown in Fig. 3 (Plate XX.). The writer has found loose pieces of these beds at the eastern end of the farm, near a quartz-reef outcrop, which there occurs in yellowish-green talcose sandstone.

The plan (Fig. 2) and sections show the positions of the various beds above enumerated, so far as the writer could locate them without a detailed survey, and especially considering the great difficulties of examination in such a hilly country. The following is a rough section of the lower beds of the Dolomite series as they appear on the Mooiplaats farm, in order of superposition:—

	Feet.
Dolomite with chert-bands	...
Quartzite and quartzitic sandstone	15
Sandstone	...
Diabase, with a quartz-reef, 18 inches thick, dipping northward 60 degrees	150
Black shale, partly granular	15
Diabase	...
Quartzitic sandstone	...

	Feet.
Dolomite, with black shale-beds at the bottom	400
Quartzite	...
Black shale	2
Diabase	25
Quartzite	15
Dolomite	...
Quartzite, bluish-grey	...
Diabase-schist	...
Diabase, resting conformably upon blue quartzite with banket, the topmost bed of the Black Reef series ...	...

The contact between this topmost bed and the lowest stratum of the Dolomite series is also exposed in the bed of the Chunies river at Z (Fig. 2, Plate XX.). The following strata occur there in order of superposition:—

	Feet.
Bands of friable red and white shale	12
Decomposed diabase	4
Shale, more solid and laminated	10
Hard diabase, with shale-bands	4
Quartzite, light-grey, with thin bands of clay	3
Decomposed diabase, resting directly on blue quartzite with banket, the topmost bed of the Black Reef series, there exposed with a thickness of 4 feet	2

The black shale here appears to have been discoloured by the diabase-intrusion. As in the last section, diabase and diabase-schist occur here at the bottom of the Dolomite-formation.

Faults.—Earth-movements have occurred in the area included in Fig. 2 (Plate XX.) producing important fissures, some of which have been filled with diabase. The direction of these fissures and joints is almost invariably from north-east to south-west. Two powerful fissures are shown in Fig. 2 (Plate XX.) as occurring in the Black Reef series westward of Chunies Poort, and these undoubtedly traverse the Dolomite-formation, which is conformable, as shown by the bend of the diabase-sheet on Doornkloof farm, and the great contortion of the banded quartzite and adjoining dolomite-beds at the south-eastern corner of Rooiboklaagte farm. Reversed faulting has probably also occurred: the symmetry of the beds which enclose the southern diabase-sheet (Fig. 7, Plate XX.) with those enclosing the northern diabase-sheet clearly points to

duplication of the beds. The section shown in Fig. 6 (Plate XX.) also shows pressure and reversed faulting. A disturbance is also shown on Staanplaats farm (Fig. 2, Plate XX.).

Reefs.—Auriferous quartz-reefs almost invariably occur either in the diabase-sheets or in the diabase-dykes. They do not extend into the adjoining strata, with one exception, in connection with the western reef (Fig. 7, Plate XX.), where small veins extend from the reef into the quartzite, 12 inches thick, but not beyond it.

The strike of the majority of the reefs in the diabase-sheets forms an angle with the run of the sheet, and consequently with the strike of the formation. It is usually from north-east to south-west, and the dip is then toward the north-west, contrary to the dip of the formation which is to the south. The strike of the reefs, in one place, is more or less at right angles to the run of the sheet and the dip is to the west. Three powerful reefs strike parallel to the run of the sheet (Figs. 2 and 8) for a considerable distance, and dip to the north. A reef, opened by a tunnel, occurs in the diabase-dyke already referred to (Figs. 2 and 8, Plate XX.); the strike is north-east to south-west, and the dip is eastward at an angle of 80 degrees.

The reefs vary in thickness from 8 inches to 2 feet, except, in some instances, where they are thicker; and their lateral extension beyond that shown on the plans is not usually easy to trace. One small reef, not extending to the surface, was exposed by a cutting.

The diabase, where these reefs occur and have been opened up (that is, near the surface and for some distance down), is generally decomposed and soft; the only exception, seen by the writer, was near the bottom of some cuttings, which exposed three reefs. The reef, in one of these instances, appeared to split into stringers on entering the harder diabase; and, in another instance, the reef was faulted in hard diabase, but it retained its thickness.

The fissures containing these quartz-reefs have most probably been produced by the cooling of the mass of diabase, and their direction synchronizes in most cases with the direction of the large fissures and joints already referred to as produced by earth-movements, namely, north-east and south-west.

A small quartz-outcrop occurs at V (Fig. 2, Plate XX.) in yellowish-green talcose sandstone, at the eastern end of the Chunies Poort West farm. These quartz-reefs consist, in part, of pure white quartz and, in part, of more or less mineralized quartz. The mineralized quartz contains oxide of iron, giving it a reddish and sometimes a dark appearance, and occasionally iron-pyrites. It is in places honeycombed, the hollows often containing oxide of iron and ochre. It sometimes exhibits stains of malachite. Siderite or spathic iron-ore occurs amongst the quartz in places.

Some of the banket-reefs, occurring in the Upper Quartzite bed, near the bottom of the dip-slope, have a very fair appearance, and contain white and some black pebbles. They are more or less auriferous.

Mr. John M. Liddell (Pincher Creek, Alberta, N.W.T., Canada) wrote that Mr. Sawyer gave an interesting account of the Chunies Poort district, which coincided with all that he (Mr. Liddell) had previously learned concerning that district in general. There seemed no room for doubt that it formed a portion of the great South African banket-field, and had been broken up in a similar manner with lines of strike running north-east and south-west. A great thickness of strata was recorded, in which apparently the pebbles were much less rounded than those of the Witwatersrand—similar in character, he (Mr. Liddell) thought, to much of the banket that he had seen in the lower Kaap valley. But there seemed to be comparatively little evidence of gold-deposits occurring among them. Presumably this district had been less subject than that of Witwatersrand to the action of hot mineral solutions on its surface, and, therefore, more breccia and less conglomerate, with less precipitation of gold or other metals had resulted. It would be of much interest to obtain evidence of the cause of the wide intervals existing between the different fragments of the original field: denudation and superincumbence of later formations would account for much, but hardly for all. A paper, on the effects of change in the contour and curvature of the globe as a whole, by some competent geologist, might illuminate the subject considerably. It would also be interesting to compare maps of the general lines of

strike, etc., occurring in South America and Australia. Mr. Sawyer's paper gave further support to the theory that the presence of diabase, or of some rock of that character, was necessary for the presence of gold in the matrix.

Mr. E. T. McCarthy said that Mr. Sawyer mentioned the occurrence of copper, which was extremely interesting, in the dolomite. He asked whether the copper was disseminated in a finely divided state, suggesting precipitation in connection with the graphite; or whether it was in a nuggety form, suggesting a molten state or more possibly segregation.

Mr. A. R. Sawyer replied that the copper occurred in the dolomite and in the graphite, disseminated and in a nuggety and arborescent form.

Mr. E. T. McCarthy suggested that the graphite might be the cause of precipitation.

Mr. A. R. Sawyer agreed that it might be so, but the graphite, which had been excavated to a depth in places of about 30 feet, extended for some hundreds of feet along what appeared, to him, to be a line of fissure, extending for many miles, judging by the contour of the country. The dolomite was cupriferous on either side of the graphite, but especially so on the western side.

The Chairman (Mr. C. C. Leach), in moving a vote of thanks to Mr. Sawyer for his interesting paper, said that it gave the members a record from Mr. Sawyer of one of the most interesting quarters of the globe.

Mr. M. Walton Brown seconded the resolution, which was cordially approved.

Mr. J. Jeffries' paper on "The Occurrence of Underground Fires at the Greta Colliery, New South Wales," was read as follows:—

THE OCCURRENCE OF UNDERGROUND FIRES AT THE GRETA COLLIERY, NEW SOUTH WALES.

By J. JEFFRIES.

Greta colliery is situated at a distance of 32 miles in a northerly direction from Newcastle, and is connected to that port by the Great Northern railway.

Geology.—The Greta Coal-measures present many points of interest. They are found, as is the case with all of the workable seams in New South Wales, in the Permo-Carboniferous formation; they are estimated to be 130 feet thick, and contain an average thickness of about 20 feet of coal. The position of the coal-seams at Greta on the west, and at Maitland on the east, shews a remarkable denudation of the seams over a considerable area of ground between these two places. There can be no doubt that at one period of geological time, the coal-seams were continuous and horizontal throughout the whole of this area: but, owing to volcanic agencies, a great upheaval occurred, forming an anticline, the centre of which is at Lochinvar; and the coal-seams thus brought within the action of powerful denuding forces, have been gradually worn away, and for a distance of about 10 miles in an east-and-west direction and for about 14 miles in a north-and-south direction the coal-seams are missing. The coal-seams are found lying at high angles, dipping from the upheaved area. On the eastern side of the anticline at East Greta, the angle of inclination reaches 60 degrees; whilst at Greta, on the west, the seams are found dipping at an angle of 11 degrees.

Faults.—Although several large faults have been located in the Greta Coal-measures, the coal-field, so far as yet proved, may be considered to be fairly free from such troubles. In the Greta colliery, the throw of the largest fault does not exceed 9 feet.

About 3,000 feet in advance of the workings, being driven in a south-westerly direction, a fault has, however, been located on the surface, with a proved upthrow to the south-west varying from about 600 to 1,000 feet. This fault has been traced to the eastern side of the anticline, and the displacement appears to increase in that direction. Patches of partly perished and soft coal are frequently found; and in many places hollows in the floor occur, shewing an uneven surface on which the vegetable matter now forming the coal-seam originally grew.

Dykes.—As volcanic agencies, assisted by denudation, have been instrumental in bringing the Greta coal-seams within a workable depth of the surface, it is reasonable to expect that igneous dykes will be encountered in the working of the seams; but, up to the present time, no igneous rocks have been found at the Greta colliery. In one of the mines on the eastern side of the anticline, however, dykes have been passed through, and are probably offshoots from the main disturbance running down the centre of the anticline.

Coal-seams.—Two seams of coal are found in the Greta colliery, known as the No. 1 or Top seam, and the No. 2 or Bottom seam; but, up to the present time, development has been confined to the upper seam. It varies considerably in thickness, but an average section is recorded in Table I. A thickness of 14 feet of strata, composed of fire-clay and sandstone, separate the Top from the Bottom seam, which is 3 feet 7 inches thick.

TABLE I.—SECTION OF THE No. 1 OR TOP SEAM AT GRETA COLLIERY.

		Ft.	Ins.	Ft.	Ins.
Roof:	Conglomerate	17	0		
				17	0
Seam:	*Second working—*				
	COAL, brassy tops	1	3		
	Band	0	1		
	COAL	1	0		
	Band	0	1		
	COAL	3	0		
				5	5
	First working—				
	Indurated clay-band, thickly studded with plant-impressions: locally termed "white stone"	0	6		
	COAL	4	0		
	Black stone band	0	6		
	COAL	4	0		
				9	0
Floor:	Fire-clay	...			
				...	

The Greta colliery is worked by shafts: the downcast and winding shaft, situated about 2,500 feet from the outcrop of the seam, is 425 feet deep, and 15 feet in diameter; the upcast and fan-shaft, situated about 1,800 feet to the rise of the downcast-shaft, is 201 feet deep, and rectangular in section, measuring 10 feet by 5½ feet. A tunnel, driven from the outcrop, also connects with the workings, forming the second outlet when required: horses too are travelled by this route.

The strata overlying the coal-seams are composed principally of very hard conglomerates and sandstones, together with several beds of shale, not exceeding 6 feet in thickness (Table II.).

TABLE II.—SECTION OF STRATA SUNK THROUGH IN THE MAIN SHAFT AT GRETA COLLIERY.

No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.	No.	Description of Strata.	Thickness of Strata. Ft.	Ins.	Depth from Surface. Ft.	Ins.
1	Brickwork	10	0	10	0	7	Blue post and shale	72	0	365	0
2	Brown sandstone ...	60	0	70	0	8	Grey rock	20	0	385	0
3	Conglomerate ...	10	0	80	0	9	Blue post	5	0	390	0
4	Light sandstone, hard	183	0	263	0	10	Conglomerate ...	17	0	407	0
5	Blue sandstone, hard	13	0	276	0	11	COAL and bands ...	14	5	421	5
6	Light sandstone ...	17	0	293	0	12	Fire-clay	...		...	

It may be pointed out, however, that in various parts of the mine, immediately overlying the coal-seam, there is a band of very coarse conglomerate, a few inches thick, followed by an extremely soft sandstone, which, when the conglomerate is broken, decomposes into a very fine sand, under the action of the atmosphere. The writer is of opinion that the presence of this sand is connected with the occurrence of the gob-fires, as, falling immediately after that portion of the seam described as the "brassy tops," it acts as a covering or blanket to the same: and being a bad conductor of heat, when chemical action occurs in the "brassy tops," the heat cannot rise to the surface and be cooled by the ventilating current, the result being a gradual increase in temperature, until the ignition-point is reached, and the mass bursts into flame.

Composition of the Coal.—The following analysis, made by the Mines Department of New South Wales, of samples taken by the State inspectors of mines, may be regarded as a fair average one: it is the mean of two samples, taken at places a considerable distance apart in the mine:—*

* *The Mineral Resources of New South Wales*, by Mr. Edward F. Pittman, Geological Survey of New South Wales, 1901, page 320.

	Per cent.
Hygroscopic moisture	1·50
Volatile hydrocarbons	40·67
Fixed carbon	49·93
Ash	7·90

The coal contains 1·87 per cent. of sulphur. The specific gravity is 1·30. The yield of coke is 57·83 per cent. The calorific value is 13·60. Compared with other New South Wales bituminous coals, the percentage of sulphur is high: the average of 77 samples, as determined by the Government analyst, being 0·541. The percentage of volatile hydrocarbons is also in excess of the average, which (in the samples already referred to) was 35·09 per cent. It would be interesting to compare the percentage of volatile hydrocarbons present, with that of British coals liable to spontaneous combustion; for, of the New South Wales coals, that which yields the highest percentage of volatile matter is most susceptible to fires of spontaneous origin.

In the old workings, the smell of sulphur is, as a rule, very pronounced, and the old gobs, in many places where the "brassy tops" had fallen, presented a "golden" appearance.

Method of Working.—The colliery has been in operation for a period of 20 years, during the whole of which time the workings have been carried out on the bord-and-pillar system, the bords averaging 24 feet in width; the pillars varying from 12 to 48 feet thick; and the cut-throughs or walls are driven to connect the bords at intervals of 105 feet.

The seam is worked in two sections; the first working extends to the indurated clay-band, and is carried forward until the cut-through is connected, when a commencement is made to work the top section in the reverse direction, or as it is termed locally, "back." The working here reaches to that portion of the seam described as "brassy tops," which sooner or later would fall, owing to the absence of support in the shape of timber.

The pyritous matter would probably be more correctly described as marcasite, and on exposure to atmospheric influences, chemical action rapidly ensues. The pyrites disintegrates, and the surrounding coal loosens and breaks up, and when walked on produces a sound similar to that noticed when ashes are underfoot. The coal surrounding the pyrites is very

jointy, and it has been observed to open up at these joints, producing conditions most favourable to the absorption of oxygen by the coal.

The writer is of the opinion that the whole of the spontaneous fires, about to be described, were caused by the action of the atmosphere on the "brassy tops."

Fire-damp.—With one exception, the whole of the collieries operating the coal-seams of the Greta Coal-measures, are worked with naked lights. Fire-damp has been found occasionally, but in very small quantities. In dealing with fires, coal-gas has been detected rising from the heated *débris*, and the writer has observed this to ignite, but to no serious extent. It must be recognized, however, that in the case of an extensive fire, there is a possibility of coal-gas being produced and ignited in sufficient quantity to cause serious trouble.

Gob-fires.—During about 16 years of its existence very little trouble was experienced from spontaneous fires in Greta colliery. The writer has been authoritatively informed that one fire did occur, but beyond the fact that, at the point of ignition, water was dripping from the roof, and that the heated matter was found to be "brassy tops," nothing definite can be stated.

No. I. Fire.—During 1897, however, trouble arose, a gob-fire being located at I. (Fig. 1, Plate XXI.). This fire occurred in an old bord, at a distance of about 100 feet from the direct course of the ventilating current. Having regard to the fact that the seat of the fire was well within the cooling action of a fairly large volume of fresh air, which is generally accepted as a preventive measure against spontaneous combustion, the cause of this fire was difficult to determine. An examination shewed that the fire had originated at a point where water, dripping from the roof, had made its appearance a few weeks previously; also that the heated material was composed of the "brassy tops." Considering that the "brassy tops" had fallen in most of the old bords in the vicinity, and that no signs of fire had been observed, the writer concluded that the water falling from the roof produced chemical action in the "brassy tops," and that the heat generated continued to increase until the ignition-point was reached. This fire

having been located in the incipient stage, and occurring in a place easily accessible, no difficulty was experienced in filling the heated material into tubs, and despatching the same to the surface.

No. II. Fire.—This fire, No. II. on Fig. 1 (Plate XXI.), occurred in one of the back bords, and presented no difficulties in being dealt with, as the material was filled into tubs and despatched to the surface, as had been done in the case of No. I. fire. Here, again, the heated material was composed of the "brassy tops," which had been covered by coal fallen from the pillar-sides, and by decomposed sandstone from the roof.

A few months after No. II. fire had been dealt with, a "creep" occurred in this section of the mine, resulting in the loss of the whole district. This "creep" liberated large volumes of water which had been held in the strata, and as the pumping machinery was not sufficiently powerful to cope with the inrush, no other course was left open but to turn the water into the dip-workings, which were eventually filled to the level marked "water-level" (Fig. 1, Plate XXI.). The creep brought about a radical change in the conditions which existed antecedent to the same, the most important being the cutting-off of the ventilation from the greater portion of the affected area. A small quantity of air circulated over the falls, naturally taking the shortest circuit to the return-airway. Shortly afterwards, black-damp appeared at several of the openings, followed by fire-stink in the return-airways.

Nos. III., IV. and V. Fires.—Several fires (Nos. III., IV. and V.) were located and dealt with (Fig. 1, Plate XXI.), but the progress in crushed ground was so slow, that it became evident that success by direct attack and removal to the surface was out of the question.

The advisability of attempting to seal off the affected area underground had been previously considered, but although the district was practically an abandoned one, the condition of the pillars, much crushed in places, and the large area of the openings (varying from 40 to about 200 square feet in section) pointed out this course as a last resource, in the event of other methods proving a failure. To isolate this section, nineteen stoppings would be

required at the points marked A to S (Fig. 1, Plate XXI.). Eventually it was decided to seal off, and the stoppings were built as shewn on the plan. Several of these stoppings were composed entirely of brickwork, others of brick and clay; also of timber and loamy sand, these latter being built where the crushed condition of the pillars rendered it impossible to make a tight joint with brickwork. The usual pipes for observation-purposes, and for drainage, were passed through stoppings, A and S.

A few days after the completion of the stoppings, black-damp appeared at several of them, and although everything possible was done to prevent fresh air from entering into the area, the writer detected extinctive gas issuing 2 years later. Cracks in the pillars were observed, and when outward pressures occurred, a light held near the cracks was immediately extinguished. The above particulars point to the conclusion that the extinction of these fires by the sealing-off process, could hardly be expected; and the writer concluded that, owing to the presence of extinctive gas within the enclosed area, owing also to the fact that the temperatures at the observation-pipes remained constant over a period of 2 years, combustion was suspended, and would probably remain latent until fresh air was supplied, but if this were allowed to occur the fires would immediately develop again.

The experience gained in dealing with these underground fires emphasizes the difficulty of coping with such evils by the sealing-off process, and also the advisability of using every endeavour to overcome them by direct attack and the removal of the heated material to the surface; for, unless the stoppings are limited in number, small in sectional area, and the pillars uncrushed, absolute extinction of the heated material cannot reasonably be expected.

As indications of the extinctive nature of the gases given off at the test-pipe at the stopping in the return-airway, the following analyses of two samples, made by Mr. F. B. Guthrie, of the Department of Mines, New South Wales, may be of interest:—Nitrogen, 87·36 per cent.; carbonic acid, 2·14 per cent.; and oxygen, 10·50 per cent. The temperature behind the stopping was 75° Fahr.; and outside the stopping, 72° Fahr.

No. VI. Fire.—This fire (Fig. 1, Plate XXI.) occurred in the old workings on the northern side of the mine. Attempts were

made to locate this fire, and remove the heated material to the surface, but unsuccessfully. Owing to the actual seat of this fire not being reached, it is difficult to give an opinion as to the cause. The writer proved conclusively that the fire was in the vicinity of the level of the water in the dip-workings, as a result of the creep in another portion of the mine already referred to; and the probability is that the action of the water on the "brassy tops" was the cause of the trouble. This was the only change in the conditions that existed in the locality for some 10 years, when no trouble was experienced; and the repeated reheating of this portion of the seam when exposed to the action of water seems to confirm this view. This fire was sealed off underground.

No. VII. Fire, caused by a Naked Light.—For some 3 years following the isolation of the old workings, no trouble was experienced from spontaneous fires, but in December, 1900, a fire occurred on the west side, at a flat or landing on a main intake-air-way and engine-road, about 1,300 feet from the bottom of the downcast-shaft, and developed so rapidly that the sealing of the mine became necessary in order to cope with the difficulty. The quantity of air circulating past the site of the fire was 45,000 cubic feet per minute. Expert opinion unanimously agreed that this fire was caused by a naked light, and subsequent examination of the mine when re-opened supported that conclusion.

Sealing the Mine.—In the discussion following a paper on "Gob-fires" by Mr. W. H. Chambers,* an important point was raised by Mr. W. N. Atkinson,† as to the various methods of sealing shafts, and the following description of the Greta-colliery sealings may be of interest. Bunton-holes were cut in the solid rock at a depth of 19 feet from the surface. Hardwood buntons, *a*, 12 inches deep by 5 inches wide, were put in, across which hardwood planks, *b*, 2 inches thick, were laid. These planks were cut to the circle of the shaft, and covered with several layers of brattice-cloth. Above this, 4 feet in depth of plastic clay, *d*, was placed, and the whole was covered with water, *e*, to a depth of 2 feet: the total thickness being 7 feet 2 inches. In the centre of the

* *Trans. Inst. M.E.*, 1899, vol. xviii., page 154.

† *Ibid.*, 1900, vol. xviii., page 465.

scaffold, a rectangular door, *c*, was placed, with an eyebolt at each corner, to which chains were attached. A wire-rope connected the chains to a windlass, *g*, which was used for lowering or raising the door. The sealings were completed with the exception of the doors, these being lowered into position simultaneously at the proper moment from the surface-level (Figs. 2 and 3, Plate XXII.). For the purpose of observing alterations in temperatures and pressures at each sealing, wrought-iron pipes, *f*, 1 inch in diameter, were carried from 6 feet below and through the sealings to the surface.

The opening at the tunnel was sealed with two brick-stoppings, 9 inches thick, between which 8 feet of sand was placed, well rammed in. The roof, sides, and floor were cut to a solid foundation, to allow of a tight joint being made with the brickwork.

The water-gauges and temperatures were recorded at each of the three sealings, and these present so many points of interest, that they are given in detail as an Appendix. A careful perusal of these records shows that the temperatures and pressures were subject to much alteration during the whole of the time that the mine remained sealed. The water-gauge on several occasions reached 1 inch, which was the depression given by the ventilating fan, when the mine was in operation and a current of about 60,000 cubic feet of air circulating per minute. The writer finds a difficulty in accounting for these changes, which might be attributed to faulty sealings, and to the consequent entry of fresh air into the mine. However, observations, taken simultaneously at each of the three sealings, indicated equal pressures in the same direction, pointing to an absence of a current of air. When outward pressures occurred at the test-pipes, extinctive gas, very sharp, was given off. After careful consideration of the temperatures and pressures conjointly, it would appear that the changes in the latter were the result of fluctuations in the former. Generally, when the temperature of the atmosphere within the mine was in excess of that outside, the pressure was inward, and *vice versa*.

About 12 weeks after the completion of the sealings, samples of the gases issuing at the test-pipes were collected, and submitted to analysis by the chemist of the Department of

Mines, with the following result: Nitrogen, 94·4 per cent; carbonic acid, 4·2 per cent.; and oxygen, 1·4 per cent. This was considered to be an excellent result, and testified to the efficacy of the sealings. A few weeks later, it was decided to make an attempt at restoration. The preliminary work being completed, the doors in the sealings were removed simultaneously at both shafts; it was noticed that a great inrush of air occurred at the downcast-shaft, but it reversed in a few minutes, bringing forth large volumes of extinctive gas, fatal to a light held 30 feet away. From later observations, the writer concluded that the inrush of air was an indication that there was still great heat at the seat of fire. On reaching that point, there was no sign of flame, but the temperature at the edge of the fallen material was somewhat high, namely, 95° Fahr. In order to prevent the fresh air from entering to the heated material, the district was isolated as far as possible by temporary stoppings, and brattice was used to convey fresh air to the workmen engaged in dealing with the fire. At the expiration of 9 days from the time of re-opening, it became evident that the attempt would prove futile, owing to the "bumping" of pillars and roof-stone, and the rapidly increasing temperature. It was decided to reseal the mine without delay; but, before this operation was completed, active combustion had developed, and smoke was issuing from the shafts.

On this occasion, the mine was allowed to remain sealed for a period of 9 months, when a second attempt was made at re-opening with successful results. The indications at the test-pipes were similar to those previously recorded. When the doors in the sealings were removed, no inrush of air occurred as previously, everything appearing stagnant; and within 14 hours from the commencement of operations the site of the fire was reached. Compared with the former attempt, the temperature was considerably less, but in a few days' time it became evident that a tremendous quantity of heated *débris* must be sent to the surface before the work could be considered a success.

In order to prevent the spread of the fire in an inbye direction, it was decided to reach the extreme end of the fired area, and there erect two brick stoppings for that purpose. This operation required considerable time, owing to the large quantities of black-damp to be removed in the old workings, and the broken

condition of the roof and sides. The erection of these stoppings, in the opinion of the writer, saved the mine, and prevented another resealing, as red-hot refuse was discovered nearly in contact with the stoppings, when the roads were cleared to these places, an operation which extended over some 6 weeks.

As the work of restoration, a few days after re-opening the mine, appeared to be doubtful, the writer decided to suspend temporarily the removal of heated débris to the surface, and proceed with the erection of stoppings at the points C, D, E, F and G (Fig. 1, Plate XXI.), in order, if possible, to isolate the affected area underground, should the fire develop to such an extent as to preclude its removal to the surface. It will thus be seen that there were only two openings, the main headings, leading to the heated ground, and the erection of stoppings at these places would isolate the districts beyond. Although the successful removal of the heated matter rendered sealing belowground unnecessary, the writer considers that in dealing with mine-fires, if there is the slightest doubt whether the direct-attack method will prove successful and sealing underground is practicable, the work of building the stoppings should be carried on conjointly with the attempt at removal; as if, at a later stage, sealing has to be resorted to, the prospects of successfully erecting stoppings decrease every moment, owing to the increase in the fumes generated by the fire. The fumes are composed principally of carbonic oxide, carbonic acid, nitrogen and sulphur dioxide, the latter of which caused great trouble in dealing with the fire in the engine-road under review.

The pillar-sides, in this case, were found to be in an incandescent state to a depth of 4 feet. For cooling purposes, a line of pipes, 2 inches in diameter, was carried from the downcast-shaft, and a line of hose-pipes of similar diameter, was connected to the rising-main pipes, 12 inches in diameter, in the shaft: the pressure of the water at the point of delivery being 205 pounds per square inch. This high pressure enabled the workmen to stand back a distance of 90 feet, and play water on the heated mass. In cases where the pillar-sides were heated, an iron bar was driven in to a depth of 4 feet, withdrawn, and the nozzle of the hose inserted in the hole: this method of cooling proved to be very effective. Operations were continued without interrup-

tion for a period of 6 weeks, when all danger appeared to be overcome. The quantity of débris filled and sent to the surface was about 8,000 tons.

Although this fire was caused by a naked light, it was very noticeable that where the "brassy tops" had been exposed to the action of flame, cooling was much more difficult than with other heated material. The effect of water on this portion of the seam was very marked. Large pieces of this impurity, which had been under water for some weeks, immediately commenced to heat when the water was drawn off, some actually breaking into flame. The writer is not aware of a recorded instance, similar to the above, which at the Greta colliery was of common occurrence.

No. VIII. Fire.—Some 7 weeks after the re-opening of the colliery, and after the main engine-road fire had been successfully dealt with, the detection of fire-stink in the return-airway at the fan-drift pointed to the existence of a gob-fire in the mine. It was located in the old workings, about 1,000 feet (Fig. 1, Plate XXI.) in a direct line from, and on the east and return-side of, the main engine-road fire. There was no direct connection between these fires, because, if such were the case, the gob-fire was burning during the time that the fire in the main engine-road was being dealt with: an utter impossibility. But, although there was no direct connection, the writer is of opinion that the heat from the latter brought about conditions favourable to the absorption of oxygen by the "brassy tops," and these continued until the ignition point was reached.

The difficulties of coping with this fire proved very great, owing to the almost inaccessible position of the outbreak; and, before a supply of water could be conveyed to the place, the flames had attained such proportions, that the sealing of the mine for the third time was found to be necessary. On this occasion, the mine remained sealed for a period of 7 months, and then another attempt at restoration was made. On reaching the fire, the conditions were found to be much more favourable than at previous re-openings; the temperature being slightly above normal at several places, indicated that, although flame had been suppressed by the sealing of the mine, and the external portion of the heated matter cooled down, the internal part of the mass was still in a heated state, and only awaited the

necessary supply of oxygen for active combustion to develop again. Several days later, smoke made its appearance at the pillar-side.

After carefully considering the condition of affairs in connection with this fire, the writer concluded that it was almost a matter of impossibility to extinguish a mine-fire of large proportions by the sealing-off process. Subsequent inspection of the colliery pointed to the fact that during the whole of the time that this place was closed, the workings were flooded with extinctive gases. When outward pressures occurred at the test-pipes, a lamp held there was immediately extinguished, and 8 days after re-opening, a light was extinguished in the fan-drift. Previous to the fires, the mine was infested with rats and other vermin, but after re-opening it no sign whatever of life was observed. These facts are enumerated, in order to show how difficult it is to extinguish a fire thoroughly by flooding with extinctive gases, generated by such fires, and confined by sealings. Where the closing-down of shafts becomes necessary, the writer is of opinion that the best result that can be expected is that combustion will be reduced after many months to such a state, that by direct attack and removal of the material to the surface, the difficulty may be overcome before reaching a serious stage. The sealing-off of this fire underground was considered and deemed to be impracticable, owing to the large number of stoppings, their exceptionally large sectional area (varying from 50 to 400 square feet); and the crushed condition of the pillars, some of which were only 12 feet thick.

Some 3 months prior to this attempt at re-opening being made, the owners had decided to surrender the lease at the end of the year, as they recognized the utter impossibility of successfully working the mine in the face of difficulties which would certainly occur; but, in order to comply with the requirements of the lease, and for that reason alone, the heated material was again filled into tubs and despatched to the surface. With the expiration of the lease in December, 1902, the mine was temporarily abandoned; the owners of the estate refusing to take over the colliery. Three weeks later, smoke commenced to issue from the upcast-shaft, and continued for some days, when the mine was again sealed down and permanently abandoned.

Methods of Extinction.—From what has been observed respecting the re-heating of the "brassy tops" by the application of water, a very important question is raised, namely: The advisability of temporarily flooding a mine for the purpose of extinguishing underground fires. Such a course in the mines working the Top seam of the Greta Coal-measures would, in the opinion of the writer, almost certainly lead to permanent abandonment, owing to the "brassy tops" re-heating and firing after the water had been drawn off. Apart from this, however, the flooding of a district for the purpose of extinguishing fires in mines on the eastern side of the Lochinvar anticline already referred to, with seams dipping at from 45 to 60 degrees, would be a very serious consideration, and probably inpracticable owing to the head of water, except perhaps in districts of a mine where the solid coal would be on the dip-side. Of course, in a colliery where the whole of the workings would be flooded, this objection does not apply. On the other hand, it is shewn by experience at the Greta colliery that, where a mine, or portion of a mine, is sealed off for the purpose of extinguishing underground fires, the process of cooling, under hard conglomerate and sandstone-rocks of low conductivity, is very slow; and if an attempt be made at restoration, within a reasonable time of sealing, the probabilities are that the workings in the immediate vicinity of the fire will be found with a temperature above the normal, and, with a regular supply of fresh air, fresh fires will develop.

In mines, where the old workings are easily accessible, the method of direct attack and removal of the heated material to the surface is unquestionably the safest, and should be adhered to, where practicable at a reasonable expense, as once a mine or portion of a mine is isolated or flooded where the Top seam is being worked, the prospects of restoration are very remote. But, although the writer considers it advisable to remove the material of these fires to the surface, it must be recognized that spontaneous fires may occur in the old workings of the steeper seams (45 to 60 degrees), where it would be an act of folly to attempt such a task. The occurrence of large falls of roof in mines working the Greta seams brings about a state of affairs favourable to spontaneous fires; these falls covering up the "brassy tops," place them outside the action of the ventilating current, while at the same time there is sufficient oxygen present to cause oxidation of the

pyrites, which continues until the mass bursts into flame. The roof-stone, being of very hard conglomerate, breaks into very large pieces, rendering their removal a very slow and costly operation. In each of the several re-openings, described, the roof-stone had fallen in places to a height of 12 feet, and explosives had to be used regularly in order to break these stones into suitable sizes for filling into tubs. In cases of this description, where the seam is highly inclined, and the seat of a fire difficult of access, it would appear that the better course is to proceed with the sealing or isolation of the district underground, if possible, without delay.

Iron-pyrites.—Probably the most interesting point established in the working of the Greta colliery, is the absolute proof that the presence of iron-pyrites ("brassy tops"), was alone responsible for the whole of the spontaneous fires described. This portion of the seam runs regularly throughout the mine, and does not occur, as is often the case, in nodules. It is regularly stratified, and when heated exhibits a variety of colours, besides giving off a substance resembling tallow, which can be worked between the fingers like putty. Careful observation points to the fact that when the "brassy tops" remain uncovered by falls of stone or by the fine sand already referred to, no trouble is experienced; but in cases where blanketing or covering occurs with substances of low conductivity, trouble will almost certainly occur.

In mines operating the Greta seam, if the "brassy tops" be absent, the probability of spontaneous fires occurring is very much reduced; at the same time, it might be pointed out that in the extensive coal-field lying to the south of Maitland, where the Greta seam is also being worked, the occurrence of the "brassy tops" in some of the collieries has been proved. The fact that the Greta colliery proved immune from spontaneous fires for a considerable number of years seems to indicate that the age of a mine is a factor to be considered in dealing with this question; and probably, where a number of mines are working a seam of somewhat similar section, spontaneous combustion might reasonably be expected to occur in the order of their age.

In the discussion following the paper read by Mr. W. H. Chambers, already referred to, instances were quoted of coal-seams, much troubled with pyrites, in which, however, no trouble

had been experienced from spontaneous heating, while other cases shewed that pyrites did cause trouble in this direction. The writer can quite understand these statements: although at first sight they may appear very conflicting, they might probably be explained by observing the effect of the atmosphere on different classes of pyrites. For some weeks, the writer had under daily observation, samples of pyrites from the Greta seam, and also from the Bore-hole seam. The latter is a bituminous coal, found in the Newcastle district of New South Wales, and is the most extensively worked seam in that colony. At many collieries, the coal contains much brass. Gob-fires have occurred in some of these collieries, but no doubt, these can be attributed to the oxidation of small coal, considerable quantities of which have been left in some of the older collieries.

The action of the atmosphere on the pyrites from the two coal-seams varied greatly. In the case of the Greta seam, the pyritous matter crumbled to such an extent that in about 5 weeks' time its cohesive properties had nearly disappeared, and a piece of pyrites, originally about 9 inches cube, had broken into pieces varying from about 1 inch square, down to fine sand. It was also observed that the pyritous matter, in a few weeks, was reduced to a degree of hardness below that of the coal surrounding it. On the other hand, the exposure of the pyrites from the Bore-hole coal-seam gave entirely different results; in fact, atmospheric influences had no effect. There can be no doubt that the pyrites from this seam is of a greater degree of hardness than the coal itself, no matter how long the exposure; and in discussing the probabilities of spontaneous fires occurring in the Bore-hole coal-seam, the influence of iron-pyrites can be eliminated.

The writer ventures to suggest that, if possible, samples of iron-pyrites from coal-seams known to be liable to fires, also from seams where pyrites is present, but fires do not occur, might be placed under similar conditions, and the changes brought about by atmospheric influences regularly recorded. This might throw some light upon a question as to which great difference of opinion exists.

Methods of Working.—The method of working the Greta coal-seam, up to the present time, has been by the bord-and-pillar

system: in fact, no other method has been adopted to any extent in the coal-mines of New South Wales. The usual practice is to drive the bords in an approximately level-course direction; and in the highly inclined seams, opportunity is taken to use the heavy gradients for self-acting haulage purposes. It would appear that, where practicable, the correct course for working the bords is in the direction of the rise of the seam. In inclined seams, if the bords are driven in a level-course direction, the conditions are favourable to flaking of coal from the sides of the pillars in the direction of their length, the result being that coal accumulates in the old bords: in fact, at the Greta colliery, this was a regular occurrence. The level-course direction is also more favourable to the grinding of the pillars. Forming the pillars in the direction of the rise of the seam gives greater support to the strata, and any movement is likely to cause the pillars to wedge; consequently, flaking from the sides of the pillars is not so marked as in the level-course direction.

The writer is of opinion that the best method of working the Greta coal-seam is on the panel-system, allowing of only two or three openings into each of the main panels, which could again be divided into secondary panels (Figs. 4, 5 and 6, Plate XXII.).

Seam worked from Shafts.—Fig. 4 (Plate XXII.) represents a proposed method of operating a seam similar to that found at Greta colliery, where the dip is 11 degrees or about 1 in 5, and where shafts are considered preferable to adits or tunnels. It will be observed that three main places are driven in a level-course direction or on the strike of the seam, forming a main intake-airway and two return-airways. At suitable distances from the shaft-bottom, pairs of places are driven to the rise on the one side, and in a cross-cut direction to the dip on the other side. Each of these pairs of places are separated by barriers of solid coal. Solid barriers also flank the main levels, and are only cut through by the dip and rise places. The places driven to the rise can be utilized as gravity-planes for haulage-purposes, and levels are driven from these parallel to the main levels. Bords are then driven off the back level to the rise of the seam. In order to reduce horse-haulage to a minimum, self-acting inclines can be arranged in convenient bords; and, as the walls are connected, the haulage-system would be extended and kept

as near to the working-faces as possible. The barriers, separating the various panels, can be extracted with the pillars from the panel above. In the event of a panel of work having to be isolated owing to spontaneous fires, two or three stoppings only would be required and the haulage-road would still be available for working the remaining panels. The dimensions of the pillars will, of course, vary according to the thickness of the strata. For the sake of clearness, the cut-throughs between the bords, and between the pairs of dip and rise places have been omitted from the plan. This method of operating the Greta seam was in progress on the western side of Greta colliery, a short time previous to the fires.

Seam worked by Tunnels.—Fig. 5 (Plate XXII.) represents a proposed method of working a similar seam, lying at an angle of 11 degrees or less, where adits or tunnels are driven from the outcrop. Three main places are driven to the dip of the seam; at suitable distances apart, levels in pairs are driven right and left along the strike of the seam; and bords are turned away from the back levels to the rise of the seam, forming panels of work. The bords are turned off narrow, in order to facilitate sealing should such become necessary, in case of spontaneous fires. In the event of one panel of work being sealed, the return-airway is preserved for use by the panels on the inbye side. The area of each panel can only be proved or determined by experience. It would appear that a certain amount of time is required during which oxidation continues, and eventually combustion occurs; therefore, an endeavour should be made to complete a panel of work before that time arrives. The cut-throughs between the main tunnels have been purposely omitted from this plan.

Inclined Seam worked by Tunnels.—Fig. 6 (Plate XXII.) represents a proposed method of operating a seam where the dip is 45 degrees. Two main tunnels are driven from the outcrop in the direction of the full dip of the seam; and, at a suitable distance down, parallel places are driven on each side, from which bords are turned away in a level-course direction. The coal from these bords is lowered to the level below by self-acting appliances. In order to facilitate the formation of self-

acting haulage-arrangements for the inbye panels, the barriers could be cut by a suitable number of narrow places where desired. In this plan, the cut-throughs between the tunnels and also between the bords have been purposely omitted.

Owing to the seam being a thick one (reaching to 32 feet), it would appear extremely advisable that the panels should be made small in area; that the top-section of the seam should not be worked until the completion of the whole workings in the panel, and then the pillars and the "brassy tops" should be worked simultaneously; that the pillars, where practicable, should be formed in the direction of the dip and rise of the seam; and that, when the pillars are attacked, their extraction should be proceeded with as rapidly as possible, in order that removal of the entire panel may be completed before the action of the atmosphere causes spontaneous combustion in that portion of the seam known as the "brassy tops."

APPENDIX—An Account of the Temperatures and the Pressures observed at the Greta Colliery, New South Wales, during the Time that the Mine was sealed down, owing to a Fire in the Workings, from December 22nd, 1900, to March 26th, 1901.

Date.	Time.	Temperatures at the		Water-gauges at the						Barometer.
				Downcast-shaft.		Upcast-shaft.		Tunnel.		
		Surface.	Downcast-shaft.	Inward.	Outward.	Inward.	Outward.	Inward.	Outward.	
1900.		Degs. Fahr.	Degs. Fahr.	Inches.	Inches.	Inches.	Inches	Inches.	Inches.	Inches.
Dec. 22	3.30 p.m.	87	82	—	0·15	—	0·15	—	0·15	—
„ 24	10 a.m.	68	76	—	—	—	—	—	—	29·78
„ 27	10 „	83	80	—	0·15	—	0·15	—	0·15	29·74
„ 28	10 „	73	80	—	—	—	—	—	—	29·61
„ 30	10 „	78	80	—	0·10	—	0·10	—	0·10	29·60
„ 31	10 „	78	80	—	0·10	—	0·10	—	0·10	29·60
1901.										
Jan. 3	10 „	86	76	—	0·10	—	0·10	—	0·10	—
„ 4	10 „	90	76	—	0·30	—	0·30	—	0·30	—
„ 7	10.30 „	90	74	—	0·10	—	0·10	—	0·10	—
„ 8	10 „	—	74	—	0·10	—	0·10	—	0·10	29·52
„ 9	10 „	—	74	—	0·10	—	0·10	—	0·10	29·52
„ 10	10 „	—	74	—	0·10	—	0·10	—	0·10	29·70
„ 11	10 „	—	74	—	0·15	—	0·15	—	0·15	29·50
„ 12	10 „	—	74	—	0·10	—	0·10	—	0·10	29·25
„ 14	10 „	—	74	—	0·35	—	0·35	—	0·35	29·38
„ 15	10 „	62	74	0·05	—	0·05	—	0.05	—	—
„ 16	10 „	—	74	—	0·10	—	0·10	—	0·10	—

APPENDIX.—*Continued.*

Date.	Time.	Temperatures at the		Water-gauges at the						Barometer.
				Downcast-shaft.		Upcast-shaft.		Tunnel.		
		Surface.	Downcast-shaft.	Inward.	Outward.	Inward.	Outward.	Inward.	Outward.	
1901.		Degs. Fahr.	Degs. Fahr.	Inches.	Inches	Inches.	Inches.	Inches.	Inches.	Inches.
Jan. 17	10 a.m.	—	74	—	0·10	—	0·10	—	0·10	—
,, 18	10 ,,	64	73	—	0·10	—	0·10	—	0·10	29·55
,, 22	10 ,,	73	74	nil	nil	nil	nil	nil	nil	29·57
,, 23	10 ,,	68	74	nil	nil	nil	nil	nil	nil	29·58
,, 25	2 p.m.	70	72	—	1·00	—	1·00	—	1·00	29·72
,, 26	10 a.m.	68	74	—	1·00	—	1·00	—	1·00	29·60
,, 27	3 p.m.	66	74	0·50	—	0·50	—	0·50	—	29·44
,, 28	10 a.m.	72	74	0·50	—	0·50	—	0·50	—	29·50
,, 29	2 p.m.	79	74	—	0·90	—	0·90	—	0·90	29·48
Feb. 4	11 a.m.	—	74	—	0·30	—	0·30	—	0·30	—
,, 5	11 ,,	78	74	—	0·80	—	0·80	—	0·80	—
,, 6	11 ,,	78	74	—	0·20	—	0·20	—	0·20	29·64
,, 7	11 ,,	78	74	—	1·00	—	1·00	—	1·00	29·70
,, 8	12 noon	94	74	—	0·50	—	0·50	—	0·50	29·60
,, 11	12 ,,	72	73	—	0·40	—	0·40	—	0·40	—
,, 13	12 ,,	94	74	—	0·50	—	0·50	—	0·50	29·50
,, 14	11 a.m.	70	74	0·30	—	0·30	—	0·30	—	29·34
,, 15	11 ,,	62	73	nil	nil	nil	nil	nil	nil	29·60
,, 16	11 ,,	70	73	0·10	—	0·10	—	0·10	—	29·72
,, 17	11 ,,	74	73	0·10	—	0·10	—	0·10	—	29·78
,, 18	12 noon	72	73	—	0·30	—	0·30	—	0·30	29 80
,, 19	12 ,,	78	73	—	1·00	—	1·00	—	1·00	29·67
,, 20	12 ,,	80	72	—	0·50	—	0·50	—	0·50	29·54
,, 20	11 p.m.	62	72	0·10	—	0·10	—	0·10	—	29·80
,, 21	2 a.m.	64	72	0·10	—	—	—	—	—	29·80
,, 21	12 noon	78	72	—	0·20	—	0·20	—	0·20	29·69
,, 21	10 p.m.	64	72	0·20	—	0·20	—	0·20	—	29·70
,, 22	12 noon	76	72	0·20	—	0·20	—	0·20	—	29·68
,, 22	12 midn't	62	70	0·10	—	—	—	—	—	29·70
,, 24	9.30 a.m.	60	68	0·20	—	0·20	—	0·20	—	29·70
,, 25	12 noon	80	72	—	0·50	—	0·50	—	0·50	29·78
,, 25	10 p.m.	62	70	0·10	—	0·10	—	0·10	—	29·74
,, 26	12 noon	78	72	—	0·20	—	0·20	—	0·20	29·75
,, 26	9.30 p.m.	64	70	0·50	—	0·50	—	0·50	—	29·80
,, 27	12 noon	76	72	—	0·20	—	0·20	—	0·20	29·75
,, 27	9.15 p.m.	64	70	0·20	—	0·20	—	0·20	—	29·78
,, 28	12 noon	76	72	—	0·40	—	0·40	—	0·40	29·75
,, 28	10 p.m.	60	70	0·40	—	0·40	—	0·40	—	29·74
Mar. 1	12 noon	78	72	—	0·60	—	0·60	—	0·40	29·77
,, 1	10 p.m.	64	70	0·05	—	0·05	—	0·05	—	29·74
,, 2	10.30 a.m.	80	74	—	0·20	—	0·20	—	0·20	29·68
,, 2	10 p.m.	68	70	—	0·10	—	0·10	—	0·10	29·60
,, 3	12 noon	92	72	—	0·80	—	0·80	—	0·80	29·53
,, 3	5 p.m.	90	74	—	0·50	—	—	—	—	29·50
,, 3	10 ,,	78	72	—	0·10	—	0·10	—	0·10	29·50
,, 4	12 noon	78	72	0·40	—	0·40	—	0·40	—	29·43
,, 4	10 p.m.	63	70	0·10	—	0·10	—	0·10	—	29·46
,, 5	12 noon	78	70	—	0·05	—	0·05	—	0·05	29·60
,, 5	10 p.m	64	72	0·50	—	0·50	—	0·50	—	29·64
,, 6	12 noon	68	72	—	0·05	—	0·05	—	0·05	29·70
,, 6	10 p.m.	63	69	0·30	—	0·30	—	0·30	—	29·74

APPENDIX.—*Continued.*

Date.	Time.	Temperature at the		Water-gauges at the: Downcast-shaft.		Upcast-shaft.		Tunnel.		Barometer.
		Surface.	Down-cast-shaft.	Inward.	Outward.	Inward.	Outward.	Inward.	Outward.	
1901.		Degs. Fahr.	Degs. Fahr.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Mar. 7	12 noon	72	72	—	0·20	—	0·20	—	0·20	29·80
,, 7	10 p.m.	58	70	0·20	—	0·20	—	0·20	—	29·80
,, 8	12 noon	78	72	—	0·50	—	0·50	—	0·50	29·80
,, 8	10 p.m.	66	70	0·05	—	0·05	—	0·05	—	29·80
,, 9	12 noon	80	72	—	0·30	—	0·30	—	0·30	29·72
,, 9	10 p.m.	70	72	—	0·10	—	0·10	—	—	29·62
,, 10	12 noon	84	74	—	0·60	—	0·60	—	—	29·52
,, 10	10 p.m.	70	72	0·50	—	0·50	—	—	—	29·48
,, 11	12 noon	62	72	0·30	—	0·30	—	—	—	29·70
,, 11	10 p.m.	60	70	0·50	—	0·50	—	0·50	—	29·70
,, 12	12 noon	62	72	—	0·30	—	0·30	—	0·30	29·78
,, 12	9 p.m.	66	*	0·10	—	0·10	—	0·10	—	29·78
,, 13	12 noon	—	—	—	0·80	—	0·80	—	0·80	29·70
,, 13	10 p.m.	—	—	—	0·05	—	0·05	—	0·05	29·64
,, 14	12 noon	—	—	—	0·50	—	0·50	—	0·50	29·58
,, 14	11 p.m.	—	—	0·40	—	0·40	—	0·40	—	29·60
,, 15	12 noon	—	—	0·20	—	0·20	—	0·20	—	29·50
,, 16	12 ,,	—	—	—	0·40	—	0·40	—	0·40	29·45
,, 17	1 a.m.	—	—	0·20	—	0·20	—	0·20	—	29·47
,, 17	12 noon	—	—	—	0·50	—	0·50	—	0·50	29·46
,, 18	12 ,,	80	77	—	0·40	—	0·40	—	0·40	29·67
,, 18	9.15 p.m.	68	76	0·50	—	0·50	—	0·50	—	29·52
,, 19	1 a.m.	66	76	0·10	—	0·10	—	0·10	—	29·52
,, 19	9.20 p.m.	68	78	0·50	—	0·50	—	0·50	—	29·86
,, 20	12 noon	80	77	—	0·60	—	0 60	—	0·60	29·76
,, 20	10 p.m.	72	77	—	0·20	—	0·20	—	0·20	29·70
,, 21	12 noon	72	77	—	0·90	—	0·90	—	0·90	29·76
,, 21	9.20 p.m.	71	76	—	0·10	—	0·10	—	0·10	29·44
,, 22	12 noon	74	77	0·40	—	0·40	—	0·40	—	29·44
,, 22	9.15 p.m.	66	76	0·50	—	0·50	—	0·50	—	29·44
,, 23	12 noon	82	78	—	0·30	—	0·30	—	0·60	29·70
,, 23	10 p.m.	66	74	0·90	—	0·90	—	0·90	—	29·60
,, 24	12 noon	75	77	—	0·20	—	0·20	—	0·20	29·76
,, 24	10 p.m.	66	76	0·60	—	0·60	—	0·60	—	29·80
,, 25	12 noon	80	77	—	0·50	—	0·50	—	0·50	29·64
,, 25	10 p.m.	65	75	0·10	—	0·10	—	0·10	—	29·82
,, 26	12 noon	74	77	—	0·60	—	0·60	—	0·60	29·78

* Thermometer broken in shaft.

Mr. George E. Lawton (Kidsgrove, Staffordshire) wrote that doubtless these fires were caused by the pyrites contained in the "brassy tops." General experience appeared to prove, when pyrites was finely disseminated in a seam, that there was great liability to spontaneous combustion; but, on the other hand, where pyrites was found in large masses, these did not become

disintegrated by atmospheric influence, and heating did not occur. Seams subject to spontaneous combustion could be successfully worked by the method adopted at the Greta colliery. The panel-system, with fire-barriers round each panel of a sufficient size to prevent crushing, and the admission of air after sealing off, appeared to constitute a method by which this seam might be successfully worked.

Mr. A. Dury Mitton (Alderley Edge, Cheshire) wrote that the section of the seam, contained in Table I., was similar to seams in which spontaneous combustion had occurred in mines in Derbyshire and Lancashire, causing gob-fires. He thought that the working of the top portion of the seam (Table I.) would have caused less liability to fire by longwall than by bord-and-pillar working, as, where coal and brassy bands are exposed, they very readily set up heating. He remembered at the Bridgewater collieries, a seam with a section of rather a similar nature, on reaching a fault, which gave off a little water, a small fire occurred at the face of a stall, which had to be shut off. He did not think that any absolute rule could be laid down, as to whether it was wiser to seal a mine or not, as much depended upon the conditions. In a fire at the Bridgewater collieries, he found, owing to the great heat in the metal-roof, 30 feet above the seam, that the only way to extinguish the fire was by the constant application of water from a hose-pipe. The water when played on the red-hot metal made it fall; this débris was then cleared away, until cool strata were reached.* Mr. Jeffries seemed to have had a difficult task to perform, and from his description he seemed to have attacked the matter in a proper fashion, and he (the writer) hoped that time would prove this to be the case.

Mr. George Farmer (Mexboro') wrote that the very interesting paper by Mr. J. Jeffries seemed to emphasize clearly the fact that seams were only subject to gob-fires under certain favourable conditions; and every seam might be liable to gob-fires if subjected to the same conditions. This seemed to be the more clearly emphasized when Mr. Jeffries said that he was of opinion that the whole of the spontaneous fires described in his paper

* "An Underground Fire at Bridgewater Colliery," by Mr. A. Dury Mitton, *Trans. Inst. M. E.*, 1897, vol. xiii., page 466.

were caused by the action of the atmosphere on the "brassy tops," or iron-pyrites. If iron-pyrites were exposed to atmospheric influence, chemical action rapidly ensued, and this chemical action was more rapid if moisture was present. The three conditions necessary for spontaneous combustion are:—(1) a supply of combustible material, (2) a necessary quantity of oxygen, and (3) a proportionate amount of initial heat. He had explained the origin of these conditions to the members.*

Again, in his (Mr. Farmer's) paper it was shewn that moisture† was a contributory factor, from the fact that it facilitated combustion by splitting up the gob-material and offering a greater exposed area to the action of oxidation. Moisture also was a carrier of oxygen, and the effect of the evaporation of the water in the gob was to make the atmosphere therein richer in oxygen and thus further facilitate combustion. Again, in a region of high temperature in a gob, the constituents of the water were disassociated and two highly explosive gases were produced, namely: carbon monoxide and hydrogen. Mr. Jeffries stated in his paper that, for about 16 years, very little trouble was experienced from spontaneous fires in the Greta colliery, and then began a series of fires. It was evident that some slight difference must have been produced in the conditions of the colliery; either in the nature of the water-bearing strata, in the strata overlying the seam, in the hardness of the seam, in the pyritous matter, in the dip, or in the working of the seam. For, unless some alteration had ensued, why was not the colliery as much liable to gob-fires during the 16 years mentioned, as after? It was a very noticeable feature in connection with these fires that many, if not all, were found in places where water was "dripping from the roof," and where the heated matter was "brassy tops." These complied with the three necessary conditions:—A supply of combustible material was present; a supply of oxygen, from the oxygen-carrying water; and an initial supply of heat, for iron-pyrites evolved heat when subjected to the disintegrating action of moisture and the atmosphere.

He (Mr. Farmer) agreed with Mr. Jeffries, when he suggested that, if possible, samples of iron-pyrites from coal-seams known

* "The Problem of Gob-fires," by Mr. George Farmer, *Trans. Inst. M.E.*, 1904, vol. xxviii., page 434.

† *Ibid.*, page 441.

to be liable to fires, also from seams where pyrites was present, but fires did not occur, might be placed under similar conditions, and the changes brought about by the atmospheric influences regularly recorded. But he would go a little further, and test the two samples under the influence of moisture and pressure, carefully noticing the hardness and texture of the two samples. It was only reasonable to believe that hardness and texture played important parts, for it was evident that the more friable the texture the more easily would the substance be split up, and the more readily would it be exposed to the action of oxidation.

He (Mr. Farmer) agreed with Mr. Jeffries, when he stated that the method of direct attack and removal of the heated material to the surface was unquestionably the safest, where practicable at a reasonable expense. Sealing off was very unsatisfactory, whilst flooding a mine, or any portion of it, was not only expensive and often ruinous, but dangerous from the fact that other fires might be originated in consequence.

In conclusion, he (Mr. Farmer) was strongly of opinion that if a study of the conditions of a mine subject to gob-fires were carefully made, and the nature of the roof and the seam, the hardness of the seam, the presence of iron-pyrites, the presence of moisture, the conditions of pressure, etc., were all taken into account, many fires would be prevented. An important item to be taken into account was the thermal conductivity of the surrounding, overlying and underlying strata, because if the overlying strata had a high conductivity, probably the heat would be dissipated harmlessly; whilst, if the overlying and underlying strata were good thermal insulators, then the heat would be stored up and trouble would eventually be experienced. The first point in the origin of a gob-fire could very often be traced to the effect of the overlying strata on the conditions of the seam.

Dr. J. S. Haldane (Oxford) wrote that some years ago* he and Mr. Meachem had brought forward evidence that the spontaneous heating of coal, the unduly high general temperature of coal-mines, and the formation of black-damp, were all due to the oxidation of the pyrites in the coal. The observations of Mr. Jeffries lent strong support to this conclusion; and the diffi-

* *Trans. Inst. M.E.*, 1898, vol. xvi., page 457; see also *The Investigation of Mine-air*, edited by the late Sir Clement Le Neve Foster and Dr. J. S. Haldane, 1905, pages 129 and 138.

culties met with at the Greta colliery appeared to be similar, in many respects, to those encountered in Staffordshire seams, and particularly at Hamstead colliery.

The disappointing effects of merely sealing up a heated area appeared to be due partly to the extreme slowness of the escape of heat through the strata above and below, and partly to the practical difficulty experienced in effectively shutting off the air. The laboratory-experiments described by Mr. Meachem and himself showed that air might be extinctive to lamps and yet nearly as effective as pure air in producing heating by slow oxidation. Air containing 17 per cent. of oxygen would extinguish a lamp: but the oxygen would need to be reduced to less than 1 per cent. in order to really check heating; and even the relatively small amount of air driven into and out of a sealed-off area by fluctuations of barometric pressure would keep an underground fire hot.

An interesting point about the analysis of the extinctive gas or black-damp from the Greta colliery was that the samples were distinctly lighter than air. This might account for the rush of gas from the downcast-shaft, when the latter was first opened after being closed for some time. The apparent fluctuations in the pressure of the air inside the mine during the period of closure may perhaps have been due to fluctuations of the external barometric pressure.

Mr. Jeffries' observations as to the effect of moisture in increasing the tendency to heating were of much interest. So far as he was aware, no satisfactory explanation of this effect had yet been given: nor had anything definite been ascertained as to the reason why some samples of pyrites oxidized far more readily than others.

Mr. W. S. Gresley (Derby) wrote that he hoped Mr. Jeffries could supply fuller information with reference to the working of the upper division of the top seam. It would also be interesting to learn what proportion of either division of this bed was actually worked, both before these fires happened and in the areas or districts affected by them. Then, one would like to know more about the physical and structural nature of the various layers of coal; if not all alike as to composition and hardness, etc. Again he (Mr. Gresley) was very interested in anything bearing upon conglomerates associated with coal-beds,

especially as to the kind, shape, size, etc., of the pebbles and boulders contained in these beds; and Mr. Jeffries' remarks about the sand derived from the breaking up of this conglomerate were rather suggestive. The loss or wastage of good coal at the Greta colliery owing to the fires, must have been very serious.

It was obvious that the Top seam was quite unsuited to the bord-and-pillar method shown in Fig. 1 (Plate XXI.); and some more economical and safer plan would, of course, have to be found for future pits, where presumably conditions practically identical with those described would obtain. The section of the seam showed that (unless some of the coal was of inferior quality and should be left underground) there was but little stone or other refuse to serve for packing or to fill partly the goaves, no matter what method of working were adopted. It was evident that the heavy rocky nature of the cover as well as that separating the seam, 14 feet thick, from the underlying seam, 3½ feet thick, would not lend itself to any form of longwall working; though he (Mr. Gresley) did not say that the longwall withdrawing method would not prove successful, if gobbing or stowing materials could be run in, just as fast as the coal was removed. Or, possibly the roof might be controlled by timbers in the form of chocks or cribs as safely and as cheaply.

He (Mr. Gresley) asked Mr. Jeffries whether he approved of the Warwickshire method of working, namely, by hills, that was, driving dip-headings to serve for proving the field, haulage, travelling and ventilation; and, when a suitable distance had been reached, and a sufficient area of coal developed, working the coal backwards outbye by longwall faces kept one in front of another, parallel and on the level towards the full rise of the measures, until the panel or block was worked out within a short distance from the main levels. By this method both the top and bottom coal-seams, if the quality of the latter was suitable, might, one would think, be taken out practically in one operation. This plan would have a splendid chance, provided that the goaves could be filled with waste, or rubbish and water. By this method, he believed that nearly all the saleable coal would be secured; gob-fires would hardly occur, and if they did, stoppings built in the solid coal would hold; a minimum of pit-room would be had; the coal would be sent out in its very best condition as to quality and size; the ventilation would be simple,

and the coal-getting concentrated; rapid development would be ensured, especially if heading-machines were used: and, of course, the number and capacity of the sections, panels, or "hills" in operation would be governed by output-requirements. Whether the hills should be driven in the top or in the bottom seam, without knowing the circumstances one could not say. He thought that it was also fairly safe to state that by the Warwickshire method, creep, squeeze, and thrust could scarcely take place; and the "brassy tops" would never, or, say, hardly ever, fall, except in the back goaf or where the air-current would be weakest and their exposure of shortest duration. Perhaps the chief disadvantage in the way of its trial or adoption in Australia would be getting miners trained to longwall working.

But, of the proposed plans given by Mr. Jeffries (Figs. 4, 5 and 6, Plate XXII.) all he would say in criticism had reference to how the bulk of the coal should be taken out, so as to secure a reasonable minimum of lost or crushed coal coupled with a minimum risk of starting underground fires. It was natural to reflect upon the nearest thing in this line of work of which one had had practical experience, where the conditions would seem to be not so very different. In this connection, he turned to America, and to some up-to-date practice in thick seams of coal lying at various angles (say 7 to 70 degrees) and associated with roofs and sometimes floors, of great strength and hardness, and where they certainly had had fires and other troubles in the past, but had fewer now. They had discovered that the proper way to work thick, steep and dangerous seams of anthracite was to prove or win the property by pairs of levels, driven right and left out of the main incline, or drifts about 300 feet or less apart, from which the bulk of the coal was worked towards the rise. The point was this: when driving the levels only so much coal was taken out (by working the rooms or stalls from the levels) as would give sufficient output per level to keep the haulage-cost within reasonable bounds; and, generally speaking, this meant that, in actual practice, they drove, say, a pair of stalls or rooms for each 600 feet, 800 feet, or even 1,000 feet driven inbye, the distance separating these pairs of places (24 feet wide) being determined by the thickness, etc., of the seam, or seams if two lay near together, being opened up. Thus by far the

greater part of the coal was removed by retreating towards the main hills, and in this way immense reserves of coal were secured for immediate withdrawal if or as required: all crush or squeeze was behind or over the goaves: the goaves could be stowed tightly by running in refuse from the upper levels or from the surface; and, of course, the product was in its best condition. A modified form of the same method was practised in the bituminous or soft-coal regions in Washington, Colorado, etc. But possibly Mr. Jeffries had made himself acquainted with American methods.

Mr. J. S. Dixon said that a seam with brassy coal at the top shewed that Mr. Jeffries had to deal with a very difficult matter; and it would be necessary, in order to avoid underground fires, to work the colliery differently, dividing it into panels with large barriers, so as to be able to isolate them in the event of combustion taking place. The mistake had been made in cutting the coal into small pillars and leaving them: this was bound to set up spontaneous combustion in a seam of that kind.

Mr. S. F. Walker (Bath) suggested that, in order to overcome underground fires, the system used in cold storage might be adopted. Where a section of a mine or even the whole mine was sealed off, it would be possible to carry carbonic acid into the place, allow it to expand there, and then pump it out at the other end. This was done in cold storage over and over again, and he thought that it was worth trying experimentally in a mine. A perfectly inert gas would be used, and as much heat as was required could be taken out in as little time as was desired.

Mr. C. C. Leach (Seghill) said that the cost of carbonic acid gas would be excessive.

Mr. S. F. Walker did not think that the quantity of heat would require a very large apparatus, especially if plenty of time were afforded, and this appeared to be available, seeing that a mine could be sealed for 6 months and even 2 years.

Mr. H. R. Hewitt (H.M. Inspector of Mines, Derby) said that the method described by Mr. Walker had been tried, but it was found that the carbonic acid gas could not be supplied in such quantities as to deal with large fires.

Mr. S. F. WALKER stated that carbonic acid gas could be obtained in any quantity from breweries.

Mr. C. C. LEACH said that the application of carbonic acid gas to underground fires had been objected to, on the ground that it was dangerous to those working at the fire, and in the mine.

Mr. J. W. LIDDELL (Coventry) asked whether the old bords were stopped off or not, when the bords were driven the length of the pillar, with proper stanks or stoppings.

Mr. C. C. LEACH moved a vote of thanks to Mr. Jeffries for his paper, which had raised an interesting discussion.

Mr. A. R. SAWYER seconded the resolution, which was cordially approved.

DISCUSSION OF PROF. R. A. S. REDMAYNE'S PAPER ON "THE MINING DEPARTMENT OF THE UNIVERSITY OF BIRMINGHAM."*

Prof. A. JARMAN (Sydney University, New South Wales) wrote that the plant and machines, tabulated in the list,† were ample for instructional work in ore-dressing, etc. The most striking feature of the equipment at Birmingham was undoubtedly the experimental coal-mine. This innovation would probably meet with a chilling reception from those people who scoff at small-scale plant (which they call "toys"), but he was sure that it would be highly serviceable for initiating students in mine-surveying, measurements and regulation of ventilation, methods of timbering, drilling and coal-cutting, and other things which could not easily be done in a laboratory. Small-scale plant had been subjected to adverse criticism in various discussions upon this subject of equipment, but those who used such plants fully appreciated the good work which they were capable of performing. It was now generally recognized that small stamp-batteries were exceedingly useful for instructional work. He (Mr. Jarman) would draw attention to the excellent work done, at the Massachusetts Institute of Technology, with a three-head battery of

* *Trans. Inst. M. E.*, 1904, vol. xxviii., page 465; and 1905, vol. xxix., page 447.

† *Ibid.*, vol. xxviii., page 473 *et seq.*

225 pounds per head.* This was practically the same weight of stamp as that used at the Royal School of Mines, London, the Birmingham University, and at Sydney University, New South Wales.

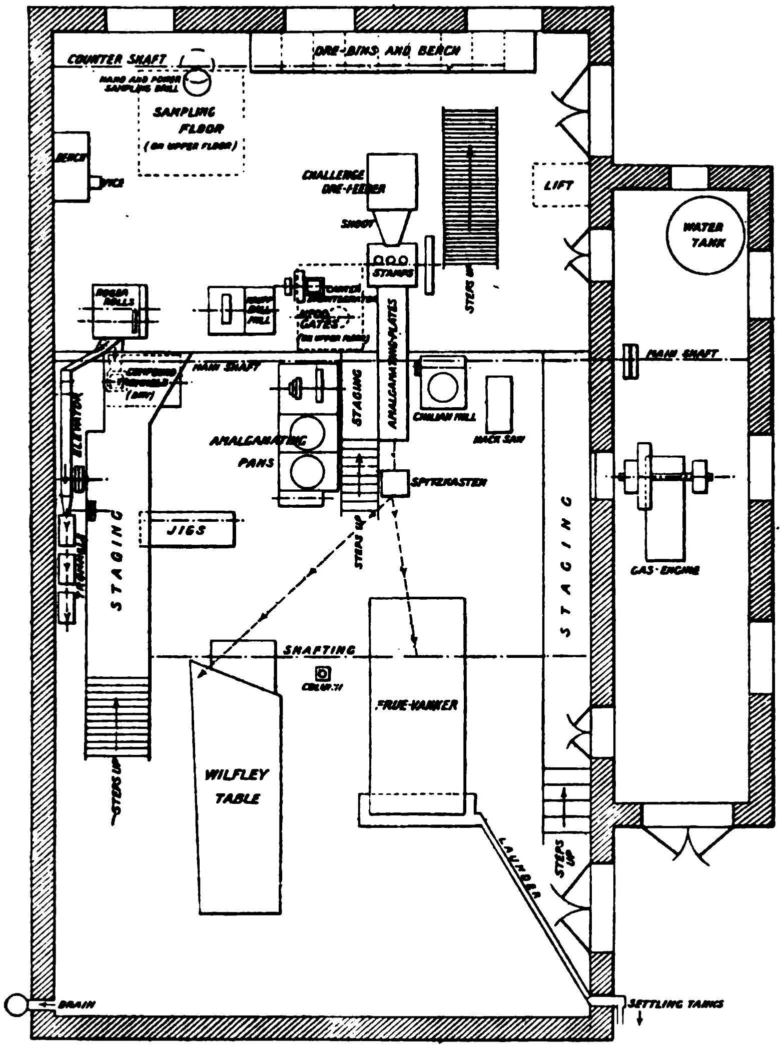

FIG. 1.—METALLURGICAL LABORATORY, SYDNEY UNIVERSITY.
SCALE, 11 FEET TO 1 INCH.

The equipment at Sydney University is very similar to that at Birmingham, but it is not so complete, as a perusal of the

* *Transactions of the American Institute of Mining Engineers*, 1903, vol. xxxiv., pages 479 to 486.

following list will show:—Sampling-floor, 6 feet by 6 feet, No. 00 Gates crusher; full-size Challenge ore-feeder on movable truck, adjustable feed-motion for use when the feeder is supplying the rolls; Roger rolls, 18 inches in diameter, arranged for either wet or dry crushing; enclosed compound trommels for dry screening; link-belt elevator; wet trommels; three-compartment jig with steel hutches; three-head stamp-battery, 232 pounds per head; silver-plated amalgamating plates, 9 feet long; spitzkasten; full-sized frue-vanner; full-sized Wilfley table; No. 0 Krupp ball-mill on iron frame; and a Carter disintegrator. The gas-engine is separated from the plant by closely fitting doors. The drying-floor is on the top of the roasting-furnace, which is placed in the yard outside. The chlorination and cyanide-plant is placed in a room separate from the milling-room. A small Wetherill magnetic separator is used in the small research-laboratory, together with the apparatus for shaking-tests, etc. The arrangement of the milling-room plant is shown in Fig. 1. The jigs and spitzkasten have just been received: they were made by Messrs. Fraser & Chalmers, from the same design as that used for similar apparatus at Birmingham.

No distinction is made between the metallurgical and mining sections of the work, as this instruction is part of the duties of the demonstrator in metallurgy and assaying, and all candidates for the B.E. degree in mining engineering must take both mining and metallurgy. The course takes four years, as shown in the accompanying copy of the time-table.

In the matter of equipment, the efficiency of the teaching staff is one of the most important considerations, and Birmingham is fortunate in possessing chairs of both metallurgy and mining, the occupants of which are prominent men in their respective professions. There is no chair of mining or metallurgy at Sydney, and these subjects are dealt with by external lecturers. It is a pity that this is so, because, however distinguished and capable external lecturers may be, their time is of too much value for them to be able to give such attention to the school as is necessary for the prosecution of systematic research. The reputation of the school depends, not only upon the quality of the graduates, but largely upon the reputation which they and the staff build up by research and by original contributions to the literature of their subjects.

TABLE I.—SYDNEY UNIVERSITY, DEPARTMENT OF ENGINEERING, MINING AND METALLURGY: TIME-TABLE OF LECTURES.

Subjects.	Lent Term.					Trinity Term.					Michaelmas Term.				
	Mon.	Tues.	Wed.	Thur.	Fri.	Mon.	Tues.	Wed.	Thur.	Fri.	Mon.	Tues.	Wed.	Thur.	Fri.
FIRST YEAR.															
Mathematics	9, 10	10	9, 10	10	10	9, 10	10	9, 10	10	10	10	10	10	10	10
Descriptive geometry	—	9	2·5	9	—	—	9	—	9	—	—	—	—	—	—
Applied mechanics	—	—	—	—	—	—	—	—	—	—	12	—	12	—	12
Chemistry I., inorganic	2·5	2·5	12	2·5	12, 2·5	11	11	11	11	11	—	2·5	—	2·5	—
Physics	—	—	—	—	—	—	12, 2·5	—	12, 2·5	12	—	11	—	11	—
Engineering drawing	11·1	11·1	—	11·1	—	2·5	—	—	—	2·5	2·5	—	—	—	2·5
SECOND YEAR.															
Physics II.	—	10	—	10	—	—	10	—	10	—	2·5	10	—	10	2·5
Geology I.	12	11	12	11	—	—	11	—	11	—	12	11	12	11	—
Mechanical engineering I.—A ...	10	—	10	—	10·1	—	—	—	—	—	10	—	10	—	10·1
Engineering drawing and design ..	11	—	2·5	—	—	9·1	—	11·5	—	9·1	—	—	—	—	—
Civil engineering I.	—	12	—	12	—	—	—	—	—	—	—	—	—	—	—
Chemistry, quantitative analysis ...	2·5	2·5	—	2·5	2·5	2·5	2·5	—	2·5	2·5	—	2·5	2·5	2·5	—
THIRD YEAR.															
Geology II.—A	9	9	9	9	—	—	9	—	9	—	9	—	9	—	—
Mineralogy	—	—	—	—	—	9·11	12	9·11	12	9·11	—	—	—	—	—
Practical metallurgy and assaying ...	—	—	—	—	—	—	—	—	—	—	—	10·5	—	10·5	—
Civil engineering III.—A	—	10, 2·5	—	10, 2·5	—	—	10	—	—	—	—	—	—	—	—
Engineering drawing and design ...	2·5	—	—	—	2·5	2·5	—	—	—	2·5	10·1	—	10·1	—	10·1
Surveying I. and III.	—	11	—	11	—	—	11	—	11	—	—	9	—	9	—
Building construction—A	—	—	—	—	—	11	—	11	—	—	—	—	—	—	—
Mechanical engineering II.—A ...	12	12	12, 2·5	12	12	—	—	—	—	—	—	—	—	—	—
Electrical engineering I.—A	—	—	11	—	11	—	2·5	—	2·5	—	—	—	—	—	—
FOURTH YEAR.															
Mining	9	9	9	9	9	9	9	9	9	9	—	—	—	—	—
Metallurgy	10	—	10	—	10	10	—	10	—	10	—	—	—	—	—
Practical metallurgy and assaying II.	11·5	10·4	—	10·4	11·5	11·5	10·4	—	10·4	11·5	9·4	9·4	—	9·4	9·4
Mining and metallurgical design ...	-	—	11·5	—	—	—	—	11·5	—	—	—	—	9·1	—	—

So far as the students themselves are concerned, short excursions from the beaten track should be encouraged, as having a high educational value; but systematic specialization and research require a larger amount of time and a broader grasp of the subject than a student possesses. Therefore, the relegation of such work to a fourth or post-graduate year,* is sound in principle and it is adhered to in this department of the Sydney University. With the object of assisting research, it is most desirable that research-scholarships for graduates should be founded as soon as possible (if this has not already been done) in order to ensure that there shall be no lack of workers.

Summer-schools are not held at Sydney, as the subjects of surveying, mining and metallurgy are dealt with by external lecturers; but he (Mr. Jarman) hoped that the day was not far distant when his University would be more favourably equipped. Such schools are of the greatest possible utility, and emphasize the practical side of the subject. They form a prominent feature of the course outlined by Prof. Redmayne, and should be particularly useful when so many mining and industrial centres are within easy reach.

The regulation requiring students to do practical work in mines before proceeding to the University is a good one. It is not in force at Sydney, but the students generally have the good sense to do practical work before reaching their third year, in which the course of metallurgy and assaying begins. He (Mr. Jarman) had tried to get such a regulation made compulsory, but without result up to the present time. Visits to works are arranged during vacations, and a few during term. Sydney is a long distance from mines and works, but the Government makes special railway-concessions to the students, the fares being ½d. per mile or slightly less.

The reputation of the Sydney school had been very good in the past, and was improving, owing to the many good positions obtained by graduates of recent years. At the same time, the number of students had decreased, owing to the recent pronounced trade-depression in Australia. In conclusion, he (Mr. Jarman) trusted that the mining and metallurgical departments of the Birmingham University would have a brilliant and useful career before them.

* *Tran. Inst. M.E.*, 1904, vol. xxviii., page 466.

DISCUSSION OF MR. DUNBAR D. SCOTT'S PAPER ON "MINE-SURVEYING INSTRUMENTS."*

Mr. S. J. POLLITZER (Sydney, New South Wales) wrote that he found great pleasure in reading Mr. Scott's interesting and instructive paper, and no doubt members ought to be doubly grateful to him: (1) for his trouble in affording so minute a description and copious illustrations of the history of surveying instruments; and, (2) for the lucid explanations of his own instrument, which no doubt would commend itself as adaptable in many instances. However, before entering into an amicable controversy regarding his instrument, he (Mr. Pollitzer) was desirous of making a few remarks on Mr. Scott's paper. He (Mr. Pollitzer) was struck with the lengthy space devoted to the three-tripod system, a system that was mostly known in literature, but hardly at all in actual practice; and in his (Mr. Pollitzer's) Australian experience of 28 years, and, previous to that, 10 years in the south-east of Europe, he never used it himself, nor did he remember having ever seen it used by any other surveyor or engineer. The avoidance of this system was only natural, although it gave the most correct results, because it was so cumbersome, involving always the transport in the field of three tripods instead of one, which, particularly in the Australian bush, was a most serious consideration. The three-tripod system had the object of replacing the true centreing of the theodolite over a station-point, certainly a most desirable object; but there was no practical utility, as the Departmental Regulations of Government Land-offices permitted a certain percentage in the misclose of a survey. It was doubtful in his (Mr. Pollitzer's) mind, even in the case of the most careful surveyor using the three-tripod system, that he would obtain a mathematically correct angular close. Not wishing to be tedious, he (Mr. Pollitzer) desired to illustrate this by stating, that quite recently he conducted a surface-survey, consisting of 86 traverses, varying from 65 links, the shortest, to more than 2½ miles, the longest side of the polygon, with a total length of periphery of over 8 miles, and the angular misclosure was not more than 3 minutes, on tying into the last station. Of course, the 3 minutes were properly distributed, and the calcu-

* *Trans. Inst. M.E.*, 1902, vol. xxiii., page 575; and 1904, vol. xxviii., page 624.

lated error in latitude and departure was certainly below the departmental allowance.

Now, this brought him (Mr. Pollitzer) to the question of correct centreing, which did not so much depend upon the surveyor as upon the style of instrument that he used; because it was always assumed that a surveyor tried to do good work. If he used a modern instrument, then, no doubt, the work would be satisfactory; but if the surveyor used antiquated instruments with four parallel-plate screws where the plummet-hook was independent of the true vertical axis of the instrument (these instruments were still very much in the market), then the case was different. He (Mr. Pollitzer) had previously referred to the question,* and in a similar discussion in the Sydney *Surveyor*, the following very sensible idea was suggested by Mr. C. J. Bullock, when using instruments of this old type:—Discard the plummet-hook entirely, bore a hole, about ½ inch in diameter, through the brass-plate carrying the plummet-hook, and a very fine hole of the thickness of a fine plummet-string through the vertical screw that connects the central pivot to the rest of the instrument, the eccentricity of centreing will then be *nil*: this alteration can be made by any mechanic for the outside cost of 2s. 6d., and instrument-makers have a hint as to how to improve their make.†

The survey of the underground workings of a mine was controlled by identically the same principles as those on the surface: the difference between the two was simply one of detail, such, for instance, as to overcome the difficulties of cramped and dangerous places, necessitating more care and attention than in surface-surveying; consequently, all principles that applied to surface also held good for underground surveys. The really great and only intricate problem in mining surveys was the correct connexion between the two, so ably expounded by Mr. Scott and many expert workers before him; but this question of connexion through the shaft had no connecting link with the point at issue, that was, the three-tripod system.

Mr. Scott's minute description of various methods of mechanical plumbing was highly interesting, but its most fascinating part was that which dealt with the survey of the Tamarack shaft, from which many useful lessons might be

* *Trans. Inst. M.E.*, 1903, vol. xxiv., page 499.

† *The Surveyor*, 1903, vol. xvi., page 117.

deduced. One was, that if two suspended wires were not parallel, the cause was solely to be ascribed to some air-current which must be eliminated; another lesson was, that both wires might be perfectly parallel, yet not truly vertical, which non-verticality might be caused by either magnetic attraction (if they were made of iron), or (if made of non-magnetic material) might be caused by air-currents; and the more important deduction still was, that if only one wire were used in plumbing, to know the reason of its not being truly perpendicular. But before knowing such reason, one had first to establish the fact that it was not vertical; the why and wherefore was a subsequent consideration; he (Mr. Pollitzer) was of opinion that if a shaft was not too deep, one should be able to ascertain the verticality or otherwise of a suspended wire with a theodolite in perfect adjustment, by the following method:—Stand the instrument on any plot and as close to the wire as circumstances may permit, and illuminate the wire with some artificial light in two places, one above the instrument and the other below; these two points being determined by the angle which the telescope forms with the horizontal plate of the instrument. If the instrument be in perfect adjustment, the telescope will move in a true vertical plane, and if both illuminated points bisect the centre of the diaphragm, then, and only then, is the wire truly vertical. Moreover, in the case of the Tamarack mine, where the shaft is over 4,000 feet deep and the deviation was about 1 inch only, even there, this method would detect the non-verticality; because, assuming that the two points are, say, 200 feet apart, its proportional deviation would be 200/4,000, equal to 0·05 inch: a measurable quantity, which could be easily detected with the telescope.

Mr. Scott's numerous perspective illustrations of his tachymeter gave one a fair idea of the merits of this instrument; however, these illustrations would have been considerably enhanced, had he in addition supplied some geometrical plans of the same, in the shape of the principal longitudinal and transverse sections; such was the established procedure amongst professional engineers, and by it one was enabled to study carefully the most important details of construction. In the absence of such detailed drawings, he (Mr. Pollitzer) would be obliged to the author if he would answer a few pertinent questions regarding the construction of this, in general, highly interesting

instrument. The detachable telescope was at about its centre provided with a collar, and this collar and the telescope could be fixed either above the permanent telescope or at one end of its horizontal axis; what the writer would like to know was whether the telescope could be revolved in the collar, or whether it was a permanent fixture: because, if it did revolve, the adjustment for collimation would be a comparatively easy matter; while, if it was a fixture, this adjustment would involve a considerable amount of work. After collimation, which was the first consideration, the second equally important one was, how did he maintain the parallelism of the axes of the two telescopes? From the description, it was made to appear that this was provided for by the maker, but one ought to bear in mind that as a rule, even with the greatest care, instruments got an occasional knock, which was an unpleasant thing for even ordinary instruments; but in this case such an accident might be very serious, because the telescope was supported at one point only, which would act as a fulcrum, and so displace it considerably. Of course, both collimation and non-parallelism could be avoided if even his (Mr. Scott's) instrument was quite out of adjustment, by making double observations, first in one position, and then turning the whole instrument 180 degrees in azimuth round the vertical axis; although a similar manipulation was, however, very ordinary in surface surveys, in a deep shaft it should be avoided.

Mr. Scott's notes were pretty extensive, both on the gravitation and optical method of plumbing a shaft, but in a diplomatic way, he refrained from definitely giving an opinion as to which of the two he preferred in principle, and that was exactly what the writer would have been glad to read. He (Mr. Pollitzer) still held that, although optical plumbing was an excellent thing in solitary and exceptionally favourable circumstances, in the majority of cases the gravitation-method was the most preferable, by means of any of the numerous appliances enumerated by Mr. Scott, or by his (Mr. Pollitzer's) two appliances.*

In conclusion, he (Mr. Pollitzer) desired to state that Mr. Scott's paper was a great acquisition to the *Transactions* of the Institute in particular, and to the literature of the subject in general.

* *Trans. Inst. M.E.*, 1903, vol. xxv., pages 17 and 24.

MR. DUNBAR D. SCOTT wrote that the following corrections were required in the second part of his paper:—*

Page 633, in line 26, "Fig. 6" should read "Fig. 5"; and in line 34, "*untersatz, g f.*"

Page 643, lines 28, 29 and 30 should read: "the sun, as with the Newton meridian dial, by equal altitudes of the sun, and by Mr. Warburton's method of observing the sun at high noon, are also reviewed. The first"; and in line 35, "polar" should read "solar".

Page 647, in line 16, "polar" should read "solar".

Page 653, in line 34, "44 inches" should read "4 inches".

Page 654, in line 19, "convex" should read "concave".

Page 655, line 20 should read: "A most notable case", etc.

Page 656, line 13 should read: "1 second: 18 seconds, the time of vibration for a pendulum 1,028 feet long. The transit", etc.

Page 657, line 17 should read: "previously set in the roof. The maximum closing error of 1⅜ inches", etc.

Page 658, in line 34, "W_1 and W_2" should read "W and W_1".

Page 659, footnote should read "Mr. A. Neustaedter".

Page 662, in line 19, "0·026 inch" should read "0·26 inch".

Page 663, in line 31, delete "said to be".

Page 667, line 27 should read: "there was no manifest horizontal component. Had the pipes lain horizontally", etc.

Page 670, line 14 should read: "equidistant on the same side of, or coincident with, the vertical line on the wall.", etc.

Page 672, in line 9, "denominated" should read "designated"; and line 32 should read: "measurements, although Mr. A. T. Mosman's modification, shown in Fig. 26, has since been successfully used".

Page 673, lines 4 to 13 should read: "settings, Mr. F. R. Hassler designed a pair of low-power nadir-microscopes. The Spanish General Ibañez, in 1858, used the Hassler method with success near Madrid.* His nadir-apparatus was made by Mr. Brunner of Paris, who supplied a centreing device, similar, in design, to the Stanley mechanical stage, shown in Figs. 32 and 33. Mr. Wm. Eimbeck drew the writer's attention to the Mosman apparatus, as exhibited in the Geodetic Section in the United States Government building at the Louisiana Purchase Exposition, in 1904. In the Mosman model, Fig. 26, the upper flange of the telescope-barrel extends outward", etc.

Page 674 should read: "Fig 26.—The Mosman Nadir-apparatus," etc.

Page 675, in line 9, "Hassler" should read "Mosman"; and in line 23, "Kladno" should read "Kladnow".

Page 677, in line 31, insert after "broken telescope" "; he acknowledges, however, that the idea is scarcely worth serious consideration."

Page 679, in line 12, "Mr. Hassler" should read "Mr. A. T. Mosman".

Page 681, in line 18, delete "accurately".

* *Expériences faites avec l'Appareil à mesurer les Bases appartenant à la Commission de la Carte d'Espagne*, by Colonel A. Laussédat, Paris, 1860.

MR. ED. LOZÉ's paper on "Electric Winding-engines at the Exhibition of the North of France, Arras, Pas-de-Calais," was read as follows:—

* *Trans. Inst. M. E.*, 1904, vol. xxviii.

ELECTRIC WINDING-ENGINES AT THE EXHIBITION OF THE NORTH OF FRANCE, ARRAS, PAS-DE-CALAIS.

By ED. LOZE.*

The Arras Exhibition provided once again an occasion for noting the progress that has been accomplished by the employment of electricity, the utilization of which is being every day more developed in France, both in its collieries and in other industrial applications. Three separate appliances have to be described under the heading of the paper: (1) the winding-engine used for a shaft-sinking at the Liévin collieries, Pas-de-Calais; (2) the winding-engine of the Lens collieries, at Lens; and (3) the winding-engine of the Ligny-les-Aire collieries, at Fléchinelle, near Estrée-Blanche, Pas-de-Calais, which is especially interesting, because of its peculiar position directly over the winding-shaft.

I.—Sinking-engine at the Liévin Collieries.

The electrical sinking-engine (Figs. 1 and 2) is intended to sink the No. 3 shaft at the No. 3 colliery of the Société Houillère de Liévin.

The winding-engine, properly speaking, consists of two rope-rolls, one of which can be allowed to run loose by removing two keys. Two brake-drums, one of which is fixed to the loose rope-roll, can be used for stopping the engine, either together or separately, by means of two band-brakes lined with wood; these are normally kept on by weights, which are lifted a little before starting the machine by powerful electro-magnets, or in place of these by a foot-brake. The rope-rolls are driven by two identical electric motors, each of 50 horsepower. They run at 500 revolutions per minute, working in series with a voltage varying from zero to 500 volts upon each, so that they can take

* Translated by Prof. Henry Louis, M.A., from *Les Mines et la Métallurgie à l'Exposition du Nord de la France*, 1905.

1,000 volts together. The difficulties of construction and maintenance would have determined the choice of two motors in preference to one in any case; moreover, if one motor should fail, the second could still do a certain amount of work. A raw-

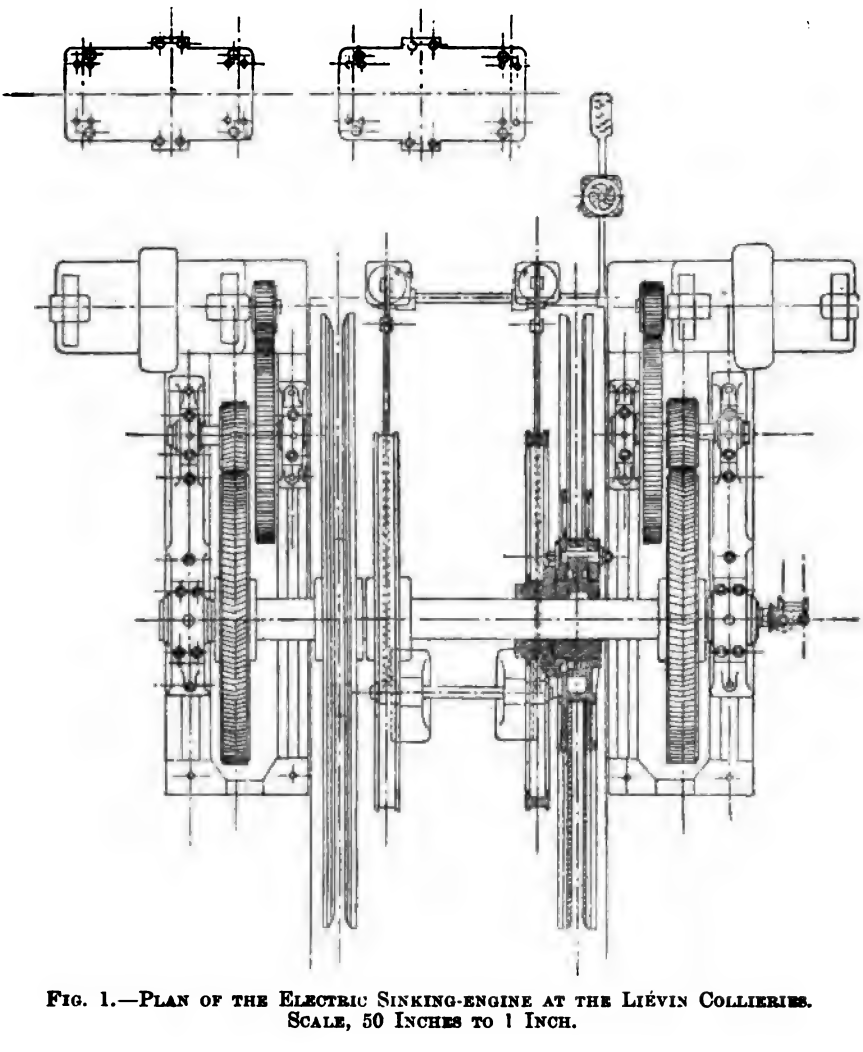

FIG. 1.—PLAN OF THE ELECTRIC SINKING-ENGINE AT THE LIÉVIN COLLIERIES. SCALE, 50 INCHES TO 1 INCH.

hide pinion is keyed upon the shaft of each of these motors. These pinions transmit their motion to the rope-rolls by means of two pairs of helical geared wheels of cast-steel, and two cast-iron wheels with ordinary gearing. An arrangement for increas-

ing or decreasing the voltage allows the speed of the rope-rolls to be varied considerably and continuously without any appreciable loss of current, waste of energy being thereby avoided. This is effected by creating at the terminals of the two motors, arranged in series, a difference of potential ranging from zero to 1,000 volts, whilst the electro-motive force of the principal circuit remains constant and equal to 500 volts, this arrangement being upon the Schuckert principle.

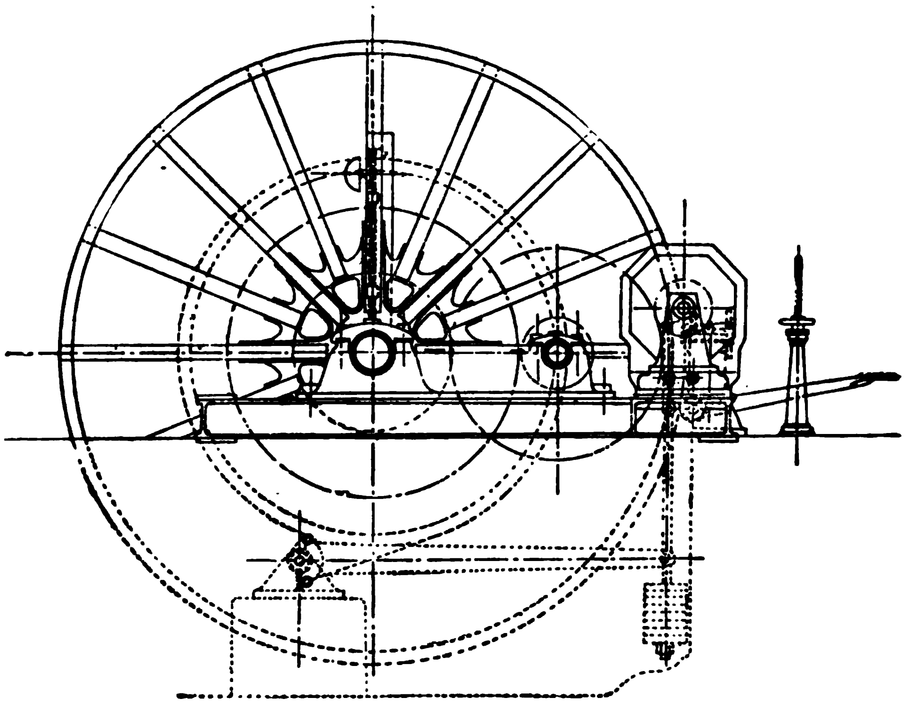

FIG. 2.—SIDE-ELEVATION OF THE ELECTRIC SINKING-ENGINE AT THE LIÉVIN COLLIERIES.
SCALE, 50 INCHES TO 1 INCH.

The entire motor-generator apparatus comprizes:—An electric motor, M, which receives the current at a pressure of 500 volts, and a generator driven by this motor by means of an elastic coupling (Fig. 3). The armature of this generator, D, is arranged in series with those of the motors of the rope-rolls. By simply regulating the excitation of the generator, D, mounted on the same shaft as the motor, M, the tension at the terminals of the latter can be caused to vary from -500 to $+500$ volts, so that between

-500 volts and zero its electromotive force is opposed to that of the circuit, whilst from zero to 500 volts it reinforces it. The resulting tension can thus vary from zero to 1,000 volts. This great variation of voltage and, in consequence, of the speed of the rope-rolls, is produced by the destruction of a feeble fraction of the current in the exciting resistances of the motor, M.

The controlling appliances comprize:—The main bi-polar switch; the exciting resistance and a starting resistance for the motor, M, worked by hand; a special resistance for exciting the generator, D, connected to one single lever, which controls the working of the rope-rolls, for running in either direction; and a contact-breaker for exciting the motors working the rope-rolls.

In addition to the usual ammeters and voltmeters, the safety-appliances comprize:—A contact-breaker for maximum current, an assistant current-interrupter, and a depth-indicator mechanically connected to the controlling-lever and to the current-interrupter.

The depth-indicator consists of a column about 10½ feet (3·2 metres) high (Figs. 4 and 5), on which is fixed a scale, B, 80 inches (2 metres) long, the graduations on which indicate the depth. Inside these, two screws, C, can each move a travelling nut, one ascending whilst the other descends. These two screws, C, are worked by means of gearing off the shaft carrying the rope-rolls. A bracket, E, can move along the scale, B, and forms the fulcrum supporting two levers, F. These two levers, F, are firmly connected by tie-rods and bell-crank levers to two other levers, H, both mounted upon the pivot of the controlling-lever, I. This latter, in whatever position it may be outside of the central position, O, is always brought back automatically to the stopping-point by the travelling nuts when these reach the end of their travel. Upon the axis of the controlling-lever, I, there is, moreover, fixed a toothed sector, J, which, by means of a pinion, a crank, K, and a connecting-rod, works the resistance which regulates the excitation of the generator, D. This same lever, I, by means of a connection, L, works the current-reverser for the armatures of the two motors for driving the rope-rolls. The automatic stopping-gear is arranged to come into action whenever the descending kibble gets down to some 10 feet (3 metres) above the place where the men are at work. In order to start the engine

again, after this automatic stop, so as to bring the kibble down to the bottom, a pawl is attached to the travelling nut. This pawl, kept in place by a spring, can by itself move the automatic stopping-gear by means of a roller, but can be pushed back by the engine-driver, so as to nullify for a few instants the automatic action, by causing it to run clear of the roller. The reserve interrupter of the main current is mounted on the top of the column, and will come into play in case the system of levers should happen to break. The travelling nuts, D, on reaching a point above their normal height, will also free the interrupter and will thus prevent an overwind.

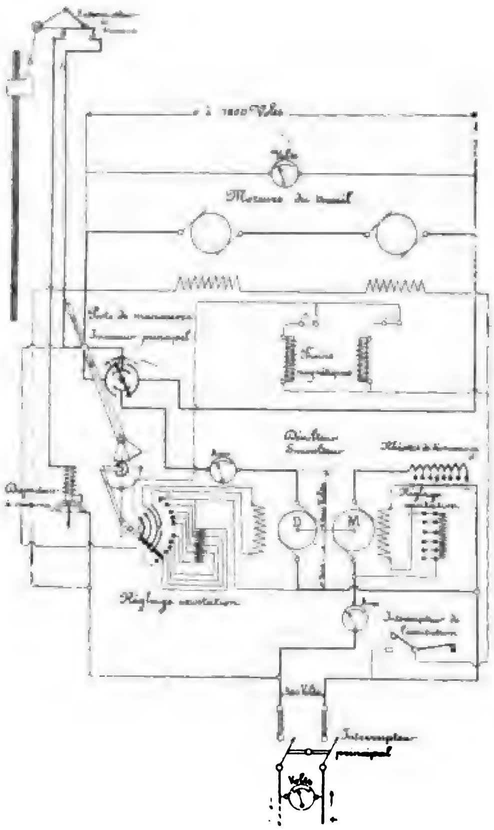

FIG. 3.—SKETCH-PLAN OF THE CONNECTIONS.

Plans of the connections are shewn in Figs. 3 and 6. It will be seen that so soon as the main switch is closed, the current passes first into the motor, M, which is set going like an ordinary motor placed in parallel. This motor drives the armature of the generator, D, in a field which is not excited so long as the controlling lever, I, is at the stopping-point, O. The mechanical brakes are blocked; at this moment the reversing lever for the exciter is on the first square contact-stud to the left (Fig. 6). This position corresponds with the short circuit of the exciter, and the contact between I. and II. is broken by a cam keyed upon the axis of the latter lever.

On pushing over, therefore, the controlling lever, I, the short circuit is cut, when it comes to the black stud. On going still further, a current of 500 volts is sent through the first round stud into the exciter, through a resistance which diminishes in proportion as the lever is pushed forward on to the first round stud of the first series. In this position, the principal current is cut off from the motors of the generator, D, the fields are fully excited, and the armature sends a pressure of 500 volts into the motor-armatures, but in the opposite direction to that of the principal current. The two pressures of equal value, but in contrary directions, mutually destroy each other, and the motors remain at rest. The magnetic brake receives a current, and frees the band-brakes. On pushing the lever over further, the excitation diminishes, resistances being successively cut in. The electromotive force produced by the generator, D, gradually diminishes, and the motors of the rope-rolls then start slowly under a pressure equal to the difference between that of the circuit and that produced by the generator, D. This difference goes on increasing in favour of the circuit, until it reaches the same value; that is to say, the generator, D, giving zero volts, the two motors of the rope-rolls are running under a tension of 500 volts or 250 for each, which corresponds to a speed equal to half of the normal speed. On pushing the lever still further over, the direction of the current in the electric field is reversed, and the current produced bv the armature, D, passes into the armatures of the motors in

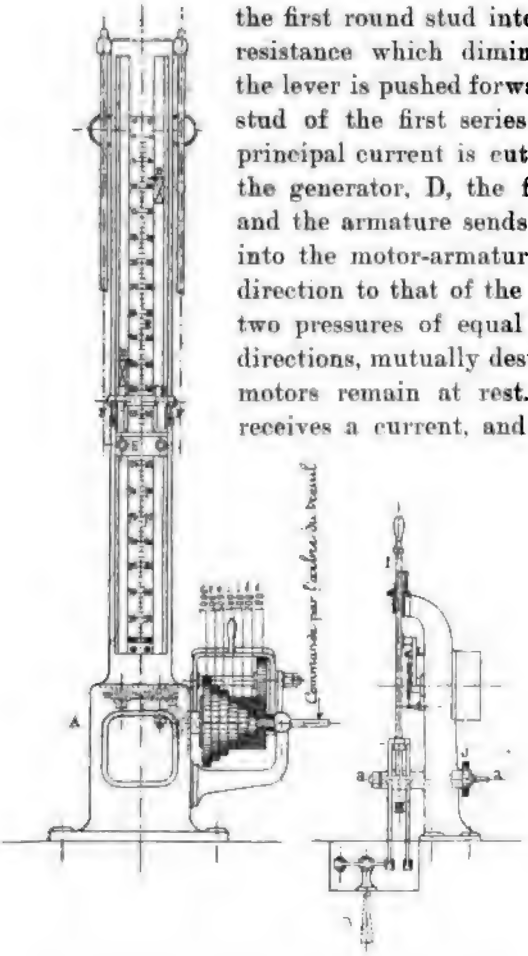

FIG. 4.—ELEVATION OF THE DEPTH-INDICATOR AND THE CONTROLLING-LEVER.
SCALE, 30 INCHES TO 1 INCH.

the direction of the current of the circuit, and is added to the latter, increasing in proportion as the resistances in the circuit of the field-magnets of the generator, D, decrease, reaching upon the last stud a tension of +500 volts, or altogether 1,000 volts at the terminals of the two motors. Their speed is then a maximum. Coming back, and taking the above-named operations in the opposite direction, a slowing-down (corresponding to the pressure diminished from 1,000 volts to zero) is gradually produced, that is to say, until the motors of the rope-rolls stop completely, which will occur when the lever is in the position indicated in Fig. 6. On going a little further still, whilst remaining upon the same stud, the current is cut off by means of the cam. The magnetic brakes then let the weights fall, and the mechanial brakes instantly stop the rope-rolls. The pedal is provided in order to lift these weights, in cases where the magnetic brakes may be out of action.

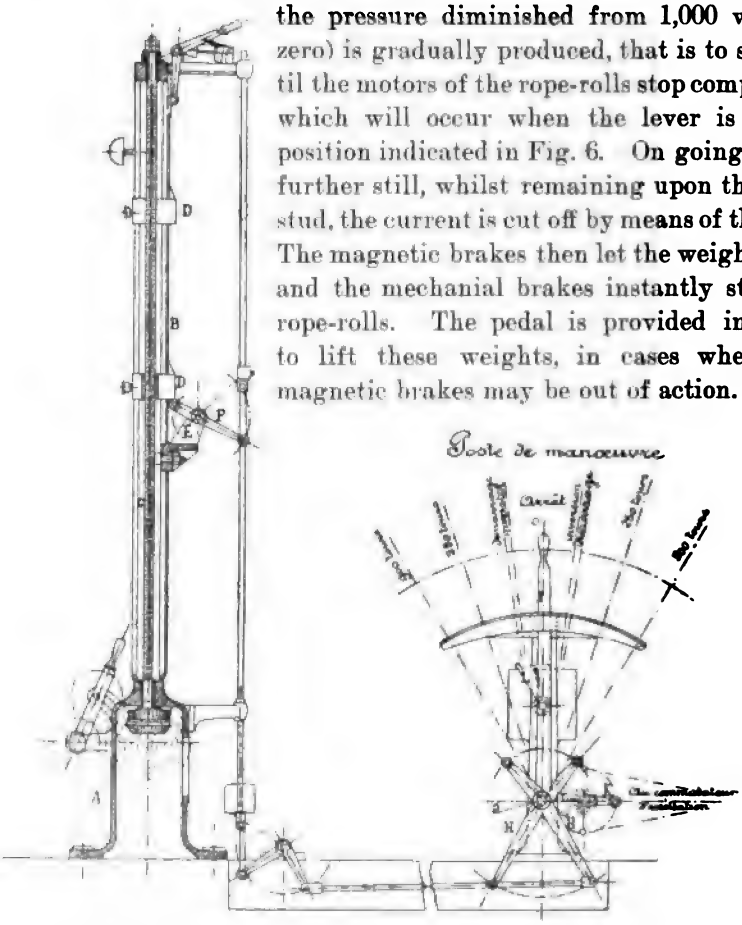

FIG. 5.—SIDE-ELEVATION OF THE DEPTH-INDICATOR AND THE CONTROLLING-LEVER.
SCALE, 30 INCHES TO 1 INCH.

It has already been admitted that one of the motors may fail: in this case the other can do a certain amount of work. The controlling lever can then only go as far as half speed; there will be no additional voltage, a bolt preventing this lever from

going further. In order to ensure a greater degree of safety in the first portion of the sinking, and especially in the first 300 feet (100 metres), which is the portion to be tubbed, several scales have been applied to the depth-indicator. With the first, the length of

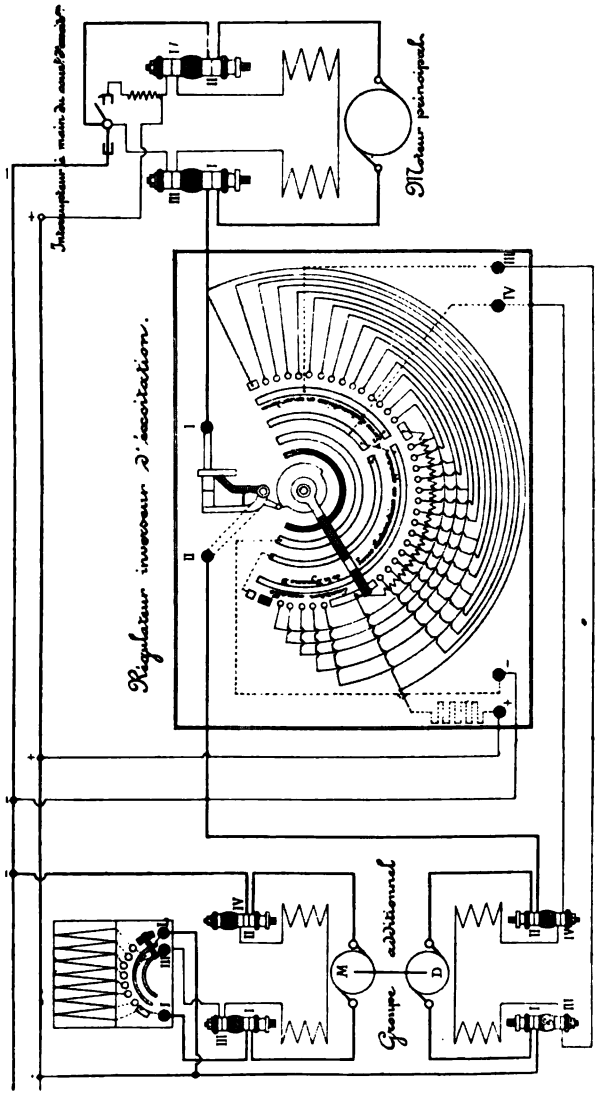

FIG. 6.—SKETCH-DIAGRAM OF THE ARRANGEMENT OF THE MOTORS AND THE SPEED-REGULATOR.

80 inches (2 metres) is divided into 100 equal parts, and will be used from 0 down to 328 feet (0 metre to 100 metres). For the second, the length is divided into 200 parts, and will be used

from 0 to 656 feet (0 metre to 200 metres), and so on. From 0 to 2,300 feet (0 metre to 700 metres) the scale is divided into 700 parts. Thus, during the greater portion of the sinking the small scale that is necessary for the finish will be avoided. Moreover, this sinking-engine, although capable of going down to a depth of 2,300 feet (700 metres), will not be used in sinking the lower portion below 1,300 feet (400 metres), as this latter will be sunk from the levels in operation. The last scale will only be used for winding, and will not have the same importance as regards speed as the first-named scales, which will apply to the sinking. In order to vary the speed of the travelling nuts corresponding to the different scales, a cone with seven stages of gearing has been introduced (Figs. 4 and 5). Every time that a scale is changed, a pinion will have to be put in gear with the spur-wheel of the corresponding diameter. A special arrangement of the automatic disengager worked by the sliding nut, D, allows the same variation of speed to be applied to all the scales. The whole of the controlling operations are performed with the same lever pushed forwards or backwards, starting from the central position, O, in order to cause the drums to run in one or the other direction.

The principal data relating to the sinking-engine are recorded in Table I.

TABLE I.—THE ELECTRIC SINKING-ENGINE AT LIÉVIN COLLIERIES.

Data.	Metric.	British.
Useful load	100 kilogrammes ...	1·97 cwts.
Total load	1,500 ,,	29·53 ,,
Length of rope	700 metres ...	2,296·63 feet
Weight of rope	2,100 kilogrammes ...	41·34 cwts.
Mean velocity of the rope per second ...	4 metres ...	13·12 feet
Power of the dynamos, about	100 horsepower ...	100 horsepower
Speed of the dynamos, per minute ...	500 revolutions ...	500 revolutions
Ratio of gearing	4 and 5 ...	4 and 5

The winding portion of the plant was supplied by Messrs. A. Fournier et fils, Génelard, Saône-et-Loire, and the electrical portion by the Société Générale d'Electricité, Creil, Oise, France.

II.—WINDING-ENGINE AT THE LENS COLLIERIES.

This electric winding-engine is intended for the No. 10 pit of the Société des Mines de Lens et Douvrin. The plant comprised a Westinghouse gas-engine (worked by a Fichet-Heurtey gas-producer set up close by), an alternator supplied by the Westinghouse Company, an electric winding-engine, and a head-gear, the whole forming one exhibit.

The Société des Mines de Lens et Douvrin had studied the most advantageous means of making use of the energy contained in the excess waste-gases produced by its coke-ovens and of that remaining in the inferior products of its washeries, dirty coal, slimes, etc. Instead of the usual methods, it substituted a suitable gas-producer, a gas-engine suitable for poor gas, and electric transmission, having been convinced by repeated experiments that, under the circumstances, these new methods were safer, more flexible, and more economical than the old ones. For this reason, the company adopted the Fichet-Heurtey gas-producer, the Westinghouse gas-engine, the Westinghouse alternator, and the electric winding-engine of the Société Alsacienne de Constructions Mécaniques at Belfort.

The winding-engine (Figs. 7 and 8) consists of two rope-rolls (for flat ropes), one fixed and the other loose, keyed upon the same shaft. The body of the rope-roll is in two parts, so that the rope can be fixed directly to the shaft. The shaft is carried by two bearings, 7 inches (180 millimetres) in inside diameter, fixed upon a frame of wrought iron, which carries the whole. The shaft is worked directly off the motor by means of a Grisson harness, having a ratio of 1 to 15, working in an oil bath. The motor acts upon the cam of the Grisson arrangement by means of a Zodel elastic coupling.

The chief data of the winding-engine are recorded in Table II.

TABLE II.—THE ELECTRIC WINDING-ENGINE AT THE LENS COLLIERIES.

Data.	Metric.	British.
Maximum useful load, unbalanced ...	1,000 kilogrammes (800 + 200)	... 19·68 cwts.
Weight of the cage	800 kilogrammes	... 15·74 ,,
Weight of the rope per running metre ...	2 ,,	... 4·40 pounds
Height of lift	257 metres	... 843·19 feet
Period of hoist	60 seconds	... 60 seconds
Speed of the rope-roll per minute ...	40 revolutions	... 40 revolutions
Mean velocity of the rope per second ...	4·000 metres	... 13·12 feet
Starting diameter of the rope-rolls ...	1·740 ,,	.. 68·50 inches
Final diameter of the rope-rolls ...	2·380 ,,	... 93·70 ,,
Speed of the motor per minute	580 revolutions	... 580 revolutions
Power created by the motor at starting	130 horsepower	... 130 horsepower
Power created after starting during running	85 ,,	... 85 ,,
Type of motor	RA26/30, at 200 volts and 50 alternations	

Brakes.—The brake-drum keyed upon the driving shaft, made in two parts, has two turned faces, each 4·72 inches (120 milli-

metres) wide, to take the brake-blocks (Fig. 8). Each of these brakes is sufficient to hold up a loaded cage at the bottom of the

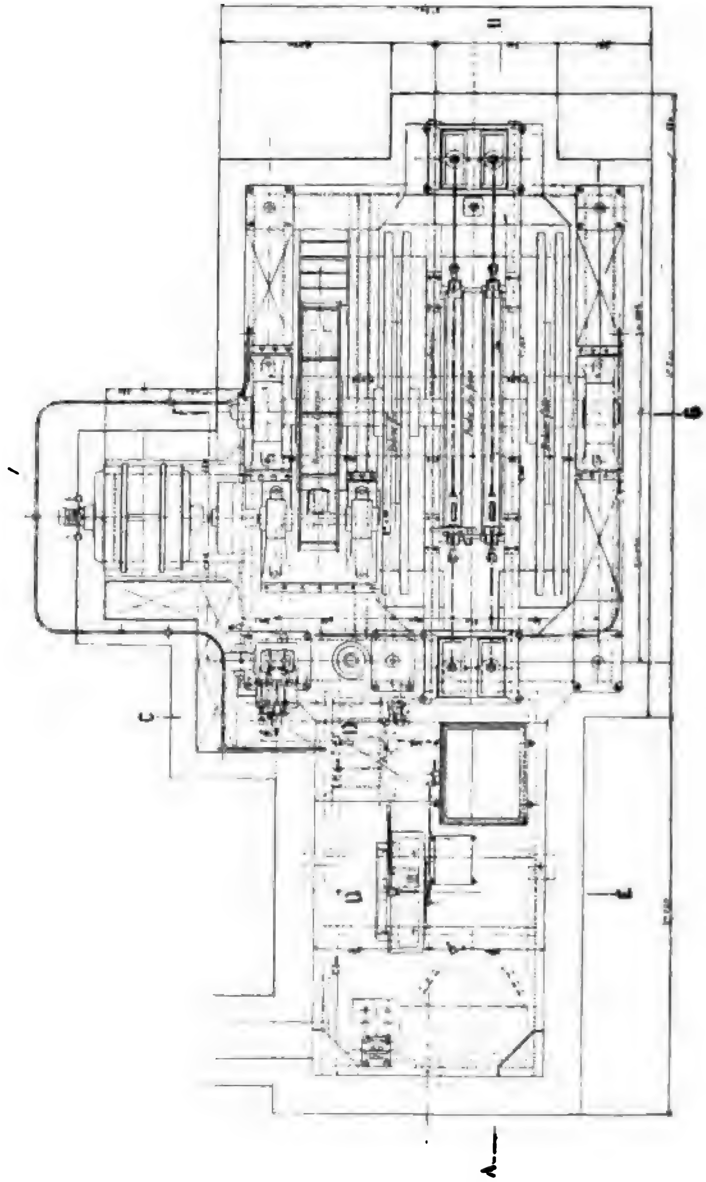

Fig. 7.—Plan of the Electric Winding-engine at the Lens Collieries. Scale, 62½ Inches to 1 Inch.

shaft without any other balancing whatever; that is to say, supposing that the second rope were not put on. The brakes are

therefore sufficient to stop, by their simultaneous action, the cage rising at full speed within a length of 10 feet (3 metres). The

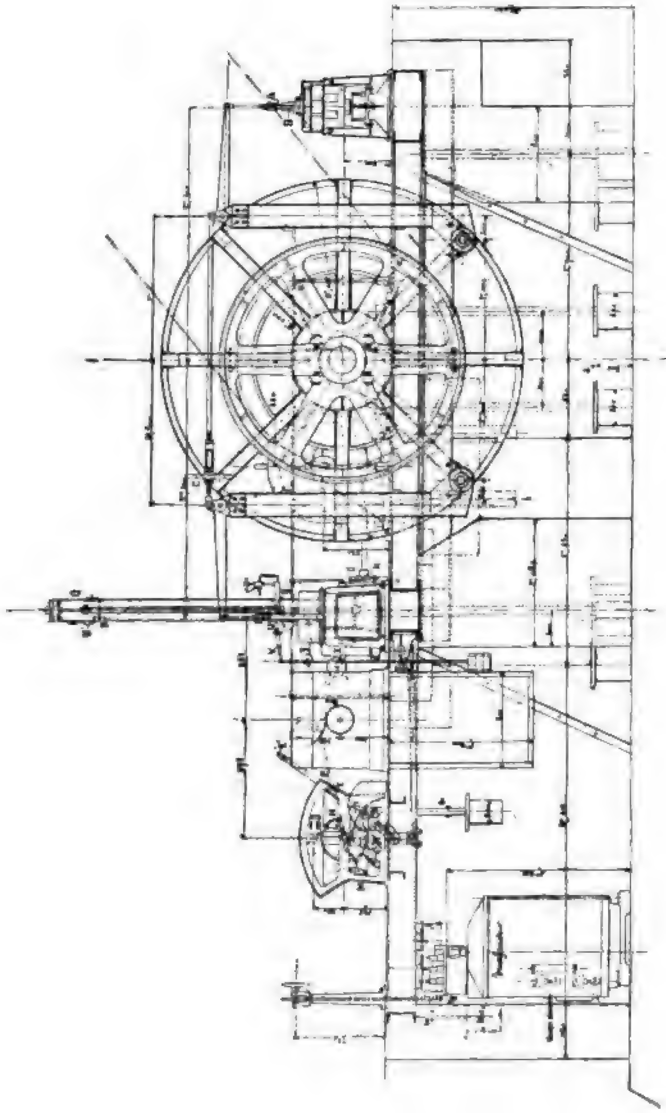

Fig. 8. Longitudinal-section, along the Line AB of Fig. 7, of the Electric Winding-engine at the Lens Collieries.
Scale, 62½ Inches to 1 Inch.

electro-magnets are furnished with dash-pots, producing a gradual pressure of the brake-blocks. One of the brakes is used as a working brake. The brakes are lifted by means of special

electro-magnets, which take off the brakes when the current passes through them, the brakes being put on by the action of weights whenever the current is interrupted. The working brake can be put on whenever the lever controlling the rope-rolls is in a vertical position, that is to say, whenever the current is cut off from the motor.

The two brakes are put on simultaneously in the following cases:—(1) When the current fails on the principal circuit. (2) When the position-indicator passes the point corresponding to the banking-out level. At this instant, a contact-breaker cuts off the current from the motor and the electro-magnets, thus bringing the rope-rolls rapidly to rest. (3) This last operation may be performed by hand at any desired moment.

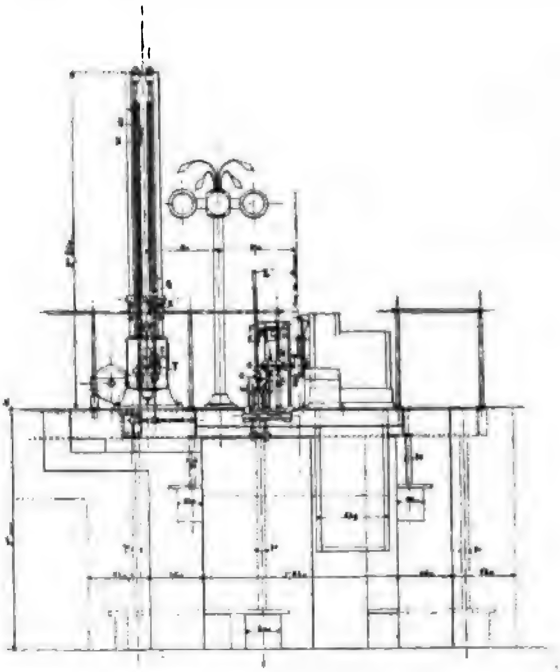

FIG. 9.—CROSS-SECTION, ALONG THE LINE CDE OF FIG. 7, OF THE ELECTRIC WINDING-ENGINE AT THE LENS COLLIERIES.
SCALE, 62½ INCHES TO 1 INCH.

The maximum play of the brake-blocks is 0·12 inch (3 millimetres); it is regulated by the length of the horizontal rod joining the two brake-levers. This rod is so adjusted that when the blocks press upon the face of the drum the dash-pots of the electro-magnets are 0·60 inch (15 millimetres) from the bottom of the air-cylinders. This motion is communicated to the ring, A, which ought to be 0·60 inch (15 millimetres) away from touching the guide, B. These rings must be adjusted on the spot (Fig. 8).

The actual useful motion of the brake-blocks is about 0·09 inch (2¼ millimetres). The horizontal rod of the working brake

is furnished with a regulator, C, allowing this brake (in case of need) to be put on by hand (Fig. 8).

Controlling Appliance.—This appliance comprizes one single hand-lever, working simultaneously the resistance, the commutator, and the working brake (Figs. 8 and 9). Its vertical position corresponds with the position of rest of the motor. A side-catch allows it at this moment to be turned about the axis, D, the effect of which is to move by means of the piece, E, the finger, F, of a rack, G; this in turn works a contact-breaker with copper brushes, which cuts off the current in the electro-magnet of the working brake, and puts on the latter. It is only possible to start after first taking off this brake again, by the opposite movement, namely, bringing the lever back into the vertical plane. Inversely, the working brake cannot be put on without having first brought the lever back to its vertical position, that is to say, without cutting off the current from the motor.

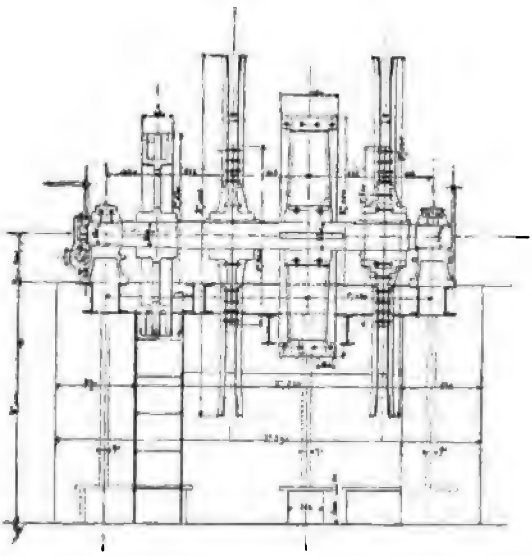

FIG. 10.—CROSS-SECTION, ALONG THE LINE FG OF FIG. 7, OF THE ELECTRIC WINDING-ENGINE AT THE LENS COLLIERIES.
SCALE, 62½ INCHES TO 1 INCH.

Moving the lever in any direction in the first place produces, by means of the sector, H, and the pinion, I, a rotation of the wheel, K, which by means of the button, L, moves the forked lever, M; the last-named works the commutator, which is thus set for going in the direction forward or backward, according as the working lever has been pushed in one or the other direction (Fig. 8). On continuing its rotation, the button, L, leaves the fork, which remains at rest with the commutator, being stopped by the circular portion of the disc, which prevents it from returning to its

mean position (it should be noted that the disc has a flat part, N, opposite the above-named button, in order to enable the fork to return to its mean position when the working lever is vertical). The resistance is worked by a crank and connecting-rod, P. It has dead studs, so as only to come into play when the commutator is set. It will be seen that, owing to the arrangement adopted, the path described over the studs of the resistances will be the same for movements of the rope-rolls in either direction. In order to regulate this appliance, it suffices to observe that when the working lever is vertical the button, L, must engage with the fork, M, this being its mean position; that is to say, its axis passing through the centre of the support.

Position-indicator.—This apparatus consists of two screws with cursors, Q, worked off the shaft of the rope-rolls by an intermediate shaft and helical spur-wheels. One of the screws corresponds to the fast rope-roll, and is regulated once for all by the tappet and disc, R. The other corresponds to the loose rope-roll, and may be regulated, as desired, by means of the flywheel, S, and the claw-disengager, T, worked by the excentric lever, U (Figs. 8 and 9).

Automatic Appliance for Slowing Down.—The indexes of the position-indicator each carry an adjustable hardened steel inclined plane, U′, which, when the cage arrives within about 33 feet (10 metres) of the banking-out level, brings into action the lever, V, which, by means of a bell-crank movement working the sector, W, moves the working lever towards the position of "stop," and consequently slows down the rope-roll (Fig. 8). If the engine-driver has not then stopped the machine completely, when the cage reaches the landings, the finger, X, fixed to the cursor, acts upon the disengager, Y, which frees the automatic contact-breaker, Z, and then abruptly stops the motor, and as well puts on both brakes. In order to re-start after such an automatic stop, the working lever is placed in the reversing position, and the automatic contact-breaker is lifted by hand for a few seconds. As soon as the rope-roll is in movement, this apparatus is automatically drawn into gear. A stud, Z′, placed upon the handle of the working lever, allows the latter to be freed from the sectors, W, used for the automatic slowing-down, and thus permits the engine-driver to work the machine absolutely as he pleases (Figs. 8 and 9).

General Arrangement of the Electric Appliances.—The high-tension main current first passes to a tripolar switch, and then to a general contact-breaker, these two appliances being placed below in the rope-rolls pit. The contact-breaker is worked by an endless chain from a working column situated upon the driving platform. From the contact-breaker the current goes to a transformer, whence one line goes directly to the resistances, the two others going to the bipolar switch for stopping at the end of the travel, which is placed upon the position-indicator. These two lines go from this interrupter to the resistance after having traversed the ammeter and the direction-indicator. From the resistance, one line goes directly to the stator of the motor, the two others traversing the reversing commutator placed by the side of the resistance, and then to the stator. Three other lines join the resistances to the rotor of the motor for its regulation and starting. The four electro-magnets of the brake are connected with the two 200 volts phases, after passing the bipolar contact-breaker.

Action of the Electric Appliances.—After the high-tension switch has been closed, the 5,000 volts current traverses the transformer, and is stepped down to 200 volts. If the bipolar switch is closed, the secondary current will pass to the terminals of the resistance. The current is set up in the motor by a motion of the lever of the starter and commutator. At the same time, and in proportion as the lever is advanced, the starting and regulating resistance is diminished in the rotor, which is progressively thrown into short circuit. The electro-magnets of the safety-brake are constantly under current so long as there is a current through the transformer, and the bipolar switch is closed. The electro-magnets of the working brake are only excited when the starting switch is closed, which, of course, is when the working lever is in the driving position. The indicator showing the direction of working consists of four lamps attached to a relay, which itself is connected with the third phase. It indicates whether the resisting couple of the rope-roll is + or −.

The electrical appliances include:—One tripolar switch for 5,000 volts; one tripolar contact-breaker for 5,000 volts; one transformer for 5,000 to 200 volts; one starting resistance; one reversing commutator; one bipolar switch for the end of the

journey; one ammeter; one voltmeter; one indicator of the direction of work, positive or negative (+ or −); and one switch for the working brake.

Fig. 7 is a plan and Figs. 8, 9 and 10 are sections of this winding-engine; Fig. 11 is a motor very much like that which is in existence at Lens; and Fig. 12 is a general view of the exhibit in the special pavilion of the Société des Mines de Lens et Douvrin.

This winding-engine has been constructed to be placed permanently at the top of a secondary shaft, and to wind cages carrying a single tub. The working conditions are detailed in Table III.

Table III.—The Electric Winding-engine at the Lens Collieries.

Data.	Metric.	British.
Height of lift	257 metres	843·19 feet
Time of hoist	60 seconds	60 seconds
Number of revolutions of the rope-rolls per lift	40 revolutions	40 revolution
Weight of the single-tub cage	800 kilogrammes	15·74 cwts.
Weight of an empty tub	200 ,,	3·94 ,,
Weight of mineral contained in a tub	800 ,,	15·74 ,,
Flat steel winding-rope:		
Width	70 millimetres	2·76 inches
Thickness when worn	8 ,,	0·32 inch.
Thickness when new	10 ,,	0·39 ,,
Weight of rope per running metre	2 kilogrammes	4·40 pounds
Diameter of the body of the rope-roll	1·500 metres	59·06 inches
Diameter of initial coiling of the rope	1·740 ,,	68·50 ,,
Diameter of final coiling of the rope	2·380 ,,	93·70 ,,
Mean velocity of the rope per second	4 ,,	13·12 feet

Head-gear and Shaft.—The arrangement is that of a staple or internal shaft, two-decked cages with claw safety-catches, one tub per deck and rail-guides. The head-gear carries pulleys covered by bonnets. The gates at the landings, normally closed, are lifted up by the cage on its arrival at bank. The keps, worked by excentrics, can be pulled back when desired, and their shafts engage with the lever of the signal-pulley by means of a pawl fitting into a mortice at either end. The bottom-landing, shown at the onsetting level, shows the hydraulic keps, the automatic gates, and the interlocking devices.

Various Interlocking Devices of the Bottom-landing.—These interlocking devices intended to ensure safety, are such that no operation that would cause any movement of the cages at the

landings can be performed, until the men in charge at the top and bottom are ready to perform the same. They realize the following conditions: —

(1) The onsetter at the main onsetting level cannot ring to advise the banksman that he is ready, unless the gates on both sides are closed.

(2) The engineer in charge of the winding-engine cannot start the cages, unless the onsetter at the main onsetting level has freed the keps at the banking-out level in order to enable

FIG. 11.—TRIPHASE MOTOR OF THE ELECTRIC WINDING-ENGINE AT THE LENS COLLIERIES.

the banksman to push them back. They cannot be freed unless the gates remain closed.

(3) The onsetter at the main onsetting level cannot open the tap of his hydraulic keps, unless the gate at the secondary banking-out side is closed, and cannot shut the tap unless the keps are at the full height of their lift at both sides of the shaft.

(4) Closing the tap of the hydraulic keps secures the heads of the kep-rams, which prevents the cage from dropping down, in case the cylinders or the pipes should burst.

(5) The bolts intended to catch the gates are held by catches, so long as the cage is not in front of its landing.

Mode of Action.—The upper deck of the cage at the pit bottom being loaded, both sets of onsetters close their gates. The chief onsetter rings to notify the engine-driver, then by throwing in his bell-lever he liberates the keps at bank, which the banksman can then throw back, so as to allow the cage to descend. The cage freeing the catches of the gate shoots in the bolts.

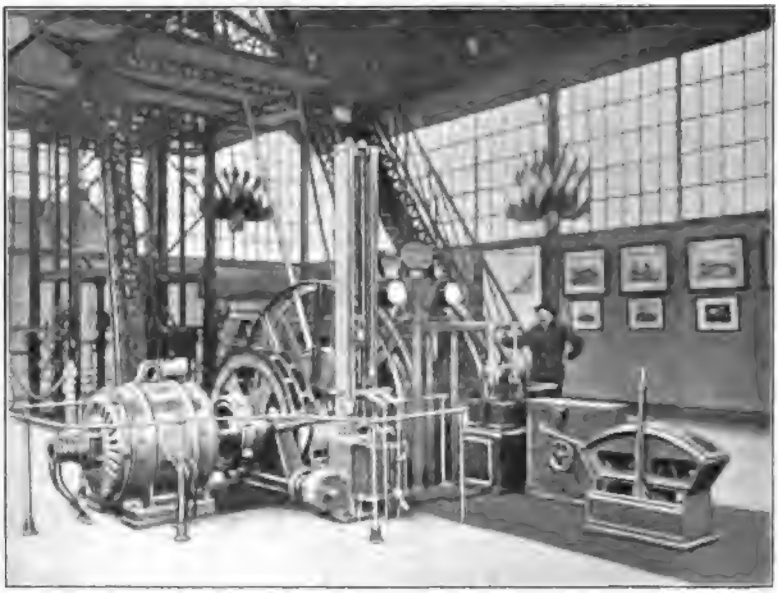

FIG. 12.—ELECTRIC WINDING-ENGINE FOR THE LENS COLLIERIES.

The hydraulic keps rise up, the onsetter on the main onsetting side closes the tap of the keps as soon as the rams have reached the top of their stroke, and thus fixes the heads of these rams. He then throws out of gear his bell-lever, so as to secure the keps at bank, an operation which he is bound to perform in order that it may be possible to open the gates. The descending cage frees the bolts, which allows of the gates being opened on the front side. The gates on the back side can only be opened if the onsetter at this side has fastened his bell-lever. The tubs having been changed on the upper deck of the cage, the chief onsetter

must work the lever of the kep-tap to allow the cage to descend. This can only be done if the onsetter on the opposite side is ready, and has closed his gate. Working the lever first frees the forks, and then opens the tap. The cage descends, the onsetter opens his gate as soon as the cage arrives at its lowest position, and the tubs are then changed. This operation completed, the onsetters at the cages close their gates, and then the principal onsetter rings for the following trip.

III.—Winding-engine at the Ligny-les-Aire Collieries.

The electric winding-engine at the Ligny-les-Aire collieries is an application of the Koepe system, with the winding-engine placed directly over the shaft. The idea of this arrangement is not absolutely new, but its application has remained rare, and its execution by means of an electrical drive is a novelty. The entire plant consists of the headgear, the electric winding-engine, the buffer-appliance, and their various appurtenances. The winding-engine forms a portion of the headgear (Fig 13). The electrical portion was constructed by the Elektrizitats-Actien-Gesellschaft, formerly Messrs. W. Lahmeyer & Co., of Frankfort-on-the-Main. The mechanical portion was constructed by the Forges, Usines et Fonderies de Haine-Saint-Pierre, Hainaut. The steel headgear was worked out in its principal parts by the Elektrizitats-Actien-Gesellschaft and its details by the Société Anonyme des Établissements Métallurgiques d'Onnaing, Nord, which took charge of its construction.

The Headgear.—The arrangement adopted allows of a considerable saving of space, and is also cheaper than the usual type. In fact, this headgear, owing to the scientific manner in which the strains are met, is no heavier than the ordinary types, weighing only about 120 tons. On the other hand, the engine-house, with its large and costly foundations, is done away with. The head-gear consists essentially of four girders sloped in two different planes, an arrangement necessitated by the lateral thrust of the loose pulley (Figs. 14 and 15). These girders rest at their base in cast-iron shoes, and their top ends are connected by the main girders which form the flooring for the engine. The shoes are placed at the corners of a square of 29·53 feet (9 metres) side, the centre of which coincides with the axis of the shaft: they are

anchored solidly in masonry-foundations. These upright girders consist of girders of box-section, formed of angle-iron, with horizontal straps and lattice-work in the form of a St. Andrew's cross. At different levels, they are tied by box lattice-girders and strutted by diagonal struts of the same shape, also arranged in the form of a St. Andrew's cross, and giving great rigidity

Fig. 13.—Electric Winding-engine for the Ligny-les-Aire Collieries.

to the whole structure. Above the banking-out level, U-shaped iron-beams guide the cage, and approach each other gradually so as to wedge the cage, if, in spite of the safety-appliances, it should be carried higher than is intended. The shaft of the winding-engine is 70·55 feet (21·515 metres) above the first landing, the latter being on the ground-level. The flooring for the engine, properly speaking, is 21·98 feet (6·70 metres) wide and

28·19 feet (8·593 metres) long, measured between the walls, and an embrasure, 8·53 feet by 9·91 feet (2·60 by 3·02 metres), forms the engineer's platform. He has within his reach the working levers and the appliances for measuring the current, for controlling the speed and the safety-appliances (Fig. 16). A second floor, placed 13·84 feet (4·218 metres) below that of the engine, carries the return-pulley, the controlling - apparatus, the depth indicator, the resistance for exciting the starting dynamo, as also the auxiliary resistance, which can be put into series with the electro-magnet of the brake. These two resistances are placed in a shed with windows situated between the two floors. No work is done here, all the operations being performed and controlled from the upper floor. In the upper shed, there is a travelling crane which can be run out on two gantries, so as to be able to pick up pieces of machinery from the ground-level, hoist them, and introduce them into the engine-room, one side of which can be opened (Fig. 15).

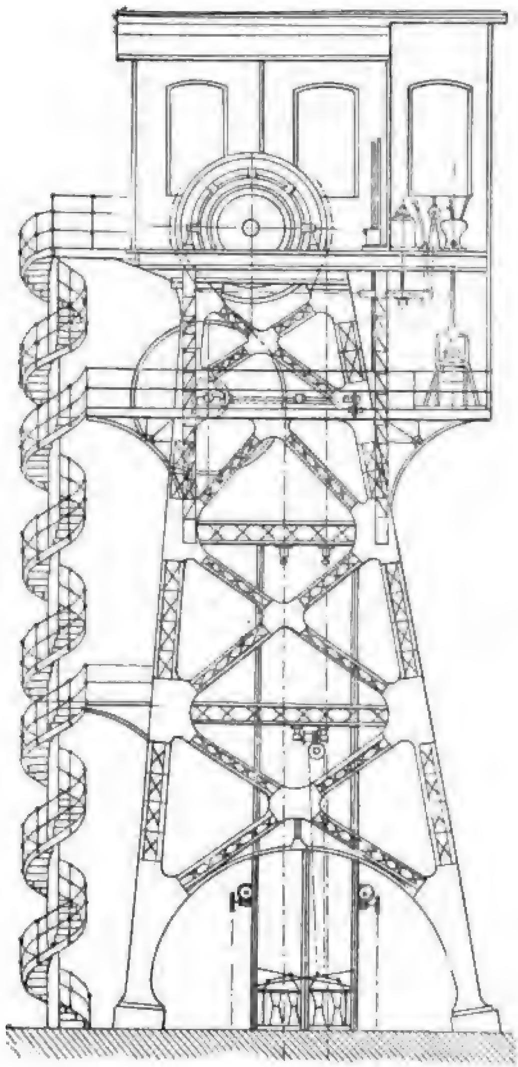

Fig. 14.—Side-elevation of the Headgear at the Ligny-les-Aire Collieries. Scale, 200 Inches to 1 Inch.

Winding-engine.—The winding-engine (Figs. 16 and 17) is the special work of the Elektrizitats-Actien-Gesellschaft. Every part of the winding-engine has been calculated to resist a load equal to the breaking-strain of the ropes, or 65 tons (65,000 kilogrammes). The engine draws, from a depth of 1,312 feet (400 metres) and at a speed of 26·25 feet (8 metres) per second, 105 tons of coals per hour. Each of the cages carries four tubs. The live load per tub is 10·83 cwts. (550 kilogrammes), so that the total live load hoisted each time is 43·30 cwts. (2,200 kilogrammes). Each wind lasts 60 seconds, and changing-operations 15 seconds, hus admitting of 48 trips per hour. The chief Koepe pulley is 13·12 feet (4 metres) in diameter. In order to get a suitable distance, namely, 3·61 feet (1·10 metres) between the axis of one cage and that of the other, a second pulley (the return-pulley) has been placed 13·12 feet (4 metres) below the principal pulley in the same vertical plane. This return-pulley is also 13·12 feet (4 metres) in diameter. The rope is a round steel-rope, 1·38 inches (35 millimetres) in diameter, and a flat steel

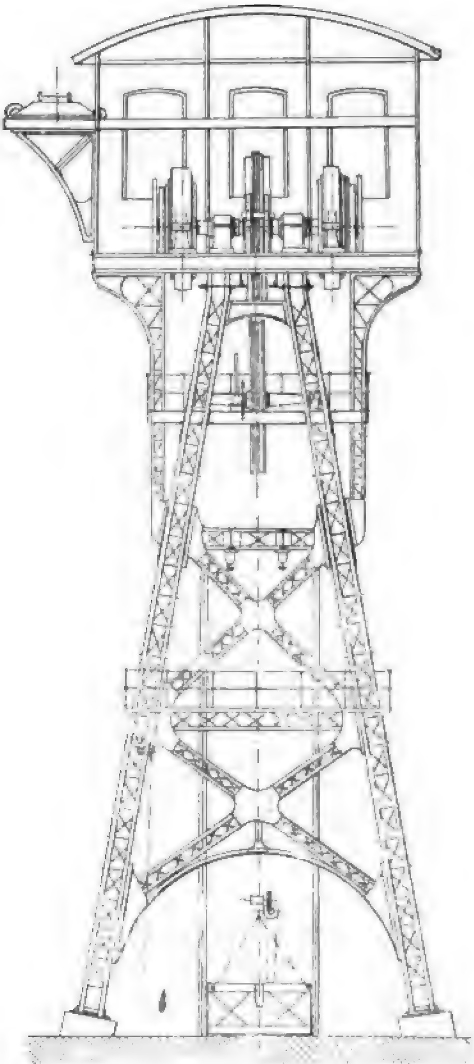

FIG. 15. END-ELEVATION OF THE HEADGEAR AT THE LIGNY-LES-AIRE COLLIERIES. SCALE, 200 INCHES TO 1 INCH.

balance-rope connects the bottoms of the two cages. Each of the pulleys has two grooves, one only being used in work; the object of the other is to receive (for the time being) the new rope when the ropes are changed, this operation being performed as follows:—The new rope, having been placed in the auxiliary groove, the rope which is to be renewed is removed, and the new rope is then placed in the working groove, which is done by lifting it by means of the travelling crane.

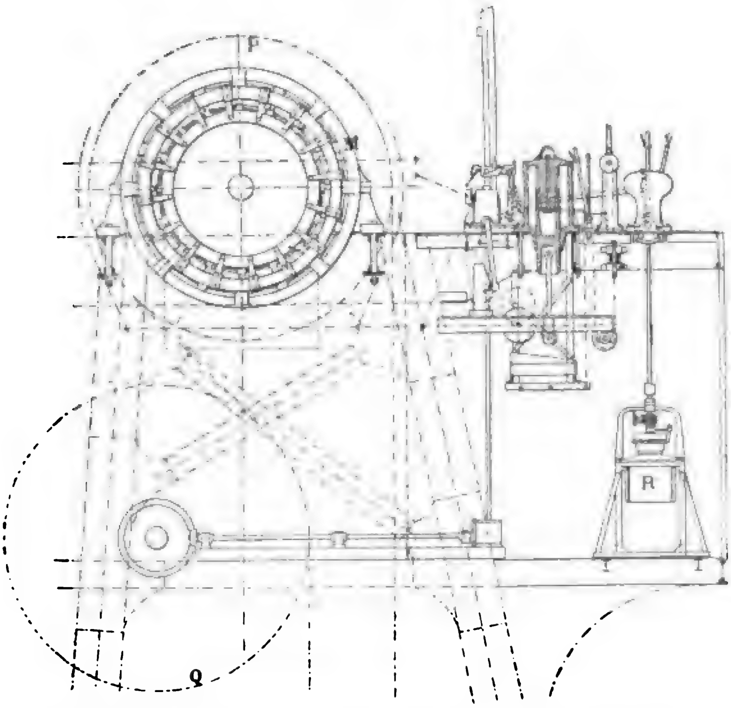

FIG. 16.—SECTION THROUGH AND BELOW THE ELECTRIC WINDING-ENGINE AT THE LIGNY-LES-AIRE COLLIERIES.
SCALE, 100 INCHES TO 1 INCH.

The principal Koepe pulley is supported by a shaft and two bearings (Fig. 17). It is driven directly by two electric continuous-current motors, capable of developing together a maximum of 500 horsepower. These two motors are situated on the shaft to the right and left of the Koepe pulley respectively. The motors make 38 revolutions per minute, whilst winding coal, at a speed of 26·25 feet (8 metres) per second: 19 revolutions per minute when men are travelling, at a speed of

13·12 feet (4 metres) per second; and three-quarters of a revolution when the pit is being examined, at a speed of 0·82 foot (0·25 metre) per second.

The maximum power given out at starting is about 600 horsepower; during the trip the output drops to 300 horsepower, being zero when the cages are at rest (Fig. 18).

Buffer-appliance.—In order to avoid the effect of shocks at the central station, a special buffer-appliance (Fig. 19) is employed

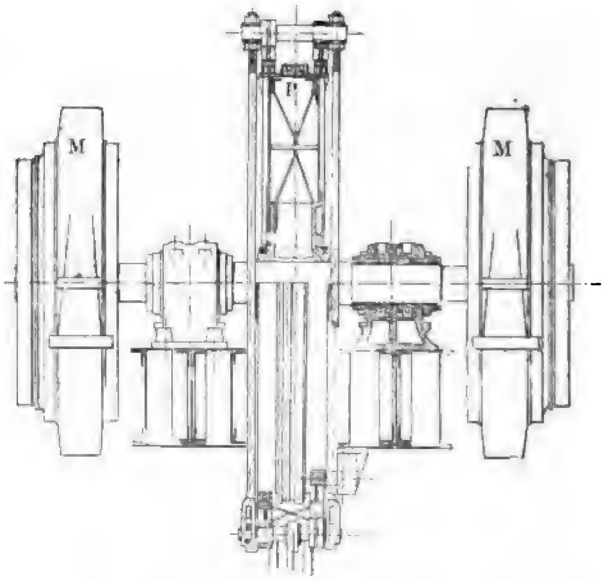

Fig. 17.—Cross-section through the Electric Winding-engine at the Ligny-les-Aire Collieries.
Scale, 70 Inches to 1 Inch.

for starting and running the winding-engine. The latter only requires during the wind about 300 horsepower permanently; its load is thus balanced. The buffer-appliance is essentially a motor-generator, constructed by the Elektrizitats-Actien-Gesellschaft (Fig. 20). It consists of a buffer-motor, P, constantly supplied with current from the circuit, of a dynamo called the starting dynamo, A, and of a dynamo for giving increased voltage, Z. These three machines, placed upon the same shaft, are fitted with a flywheel, S, which weighs 7 tons, and runs with a maximum circumferential velocity of 262·47 feet (80

metres) per second, corresponding to the maximum speed of the buffer-appliance of 500 revolutions per minute. The flywheel consists of a disc of cast-steel, forged and turned on all its faces. The dynamo, Z, causes a variation of voltage at the terminals of the buffer-motor, and accordingly varies the speed of the latter. The Lahmeyer dynamos which enter into this buffer-group are exceedingly strongly built, and every portion that can have any influence upon the safety of working is of ample dimensions. Special care has been taken in the manufacture, in order to obtain sparkless running, a minimum of heating, and the minimum loosening of the brushes. The rotating armature is built

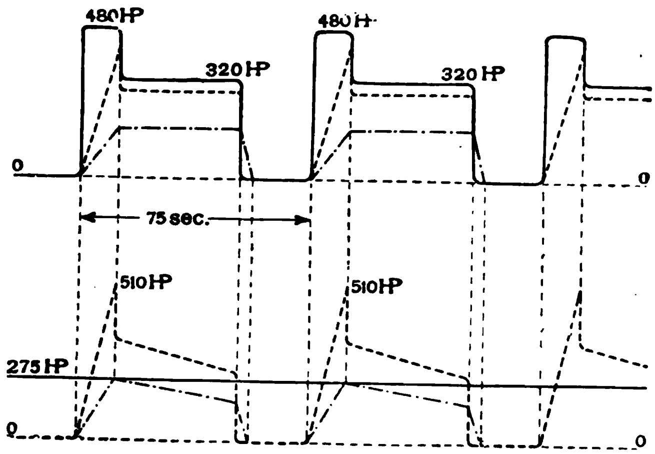

FIG. 18.—DIAGRAMS OF THE POWER AT THE CENTRAL PLANT, ———; THE POWER OF THE MOTORS, - - - - -; AND THE VELOCITY OF THE MOTORS, —·—·—·

up of a number of thin iron sheets separated by an insulator; and the magnetic properties of these sheets of iron are being constantly tested in the laboratories of the company. Ventilating canals, judiciously introduced, enable the metallic masses to be kept thoroughly cool, so that in no case, with an uninterrupted run of 10 hours, does the increase of temperature of any part exceed 113° Fahr. (45° Cent.).

The winding is of the drum-type. In these large machines, the windings, made of strip-copper, are bent upon moulds before they are put in place, which allows the number of soldered joints to be diminished, and at the same time allows of the coils being interchanged and of repairs being executed with ease. These elec-

tric conductors, after having been insulated, are placed in grooves slotted out in the periphery of the armature. By this means, in addition to the perfect insulation, a high degree of mechanical safety is obtained, for the conductors occupy an absolutely rigid position, which prevents any deformation. In order to neutra-

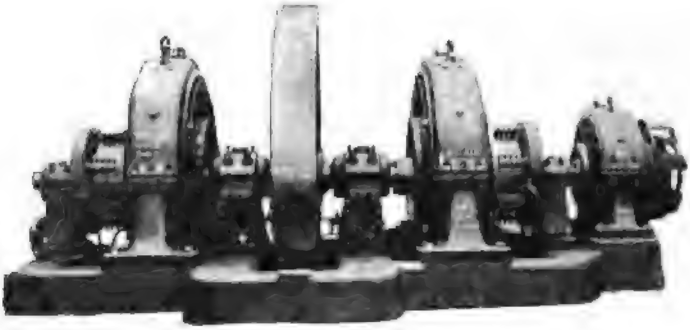

FIG. 19.—BUFFER-APPLIANCE.

lize any effects of centrifugal force, the whole of the armature is protected by several strips of flat iron, easily removable. The field-magnets are made of a special cast-steel, almost completely surrounding the armature, and thus preventing any mechanical

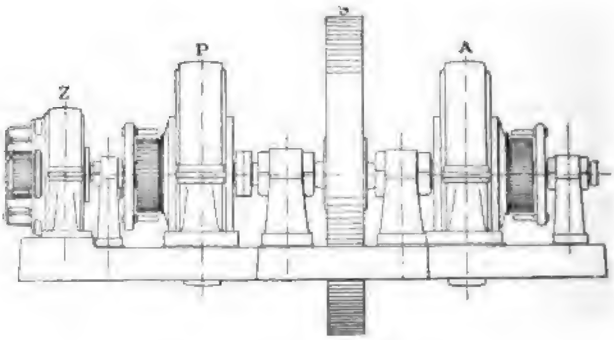

FIG. 20.—BUFFER-APPLIANCE.

injury. The poles of the magnets are simply bolted to the base, and receive the exciting coils. In order to strengthen them and give them a better appearance, these field-magnets are protected by a strong zinc frame, covered with micanite or some equivalent insulator. The commutator being the most delicate portion of a dynamo, is most particularly constructed and dimensioned. The

strips are of drawn copper, and separated from each other by a mica-insulation. The mechanical arrangement is such, that it is possible to withdraw a portion of these strips without dismounting the whole commutator. Rational distribution of losses in the copper and iron, as well as the mechanical construction of all the parts, secure to this machine a high output, even when only working under a partial load. In addition, the liberal proportions allow of a considerable temporary overcharge, without any dangerous degree of heating, or without the production of sparks at the commutator, the brushes maintaining their normal position. In order to vary the speed of the winding-engine, the starting dynamo, A, is set to work. Its excitation is graded by means of the principal starting apparatus. As has been stated, this exciting resistance is placed on the starting appliances in the lower shed, the lever extending into the upper shed. In addition to the different contacts, the object of which is to throw in gradually the successive elements of the resistance, this resistance has an exciting commutator. The starting dynamo, A, can thus furnish current under a pressure ranging from 0 to 525 volts, which, according to the position of the commutator, may therefore be added to or subtracted from the voltage applied to the terminals of the buffer-motor (Fig. 21). The two winding-motors receive together a tension ranging from $(525-525=)$ 0 to $(525+525=)$ 1,050 volts. When the maximum voltage (1,050) is reached, the motors run at their full speed. The voltage may be brought back to zero by means of the principal working lever, when the motors no longer receive any current. The working gear allows any

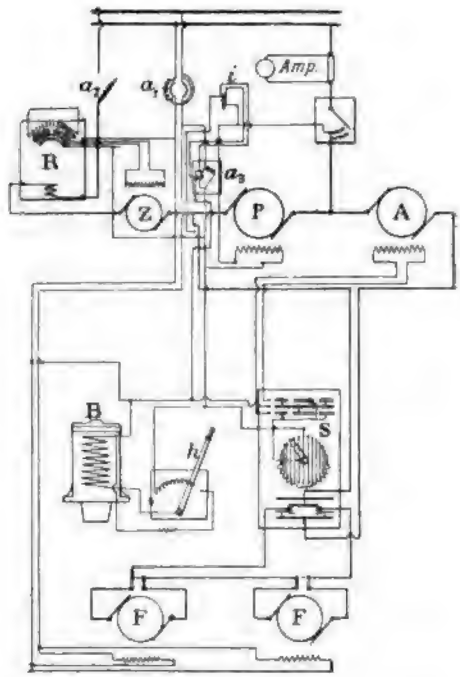

FIG. 21.—SKETCH-PLAN OF THE CONNECTIONS.

desired speed to be obtained, almost independently of the load. The regulation is effected entirely by the excitation produced by an insignificant amount of current, and without causing any serious losses of energy.

Another commutator, also connected with the working lever, has for its object to reverse the direction of rotation of the winding motors. The starting of the buffer-motor is made by means of an ordinary starting resistance. In order to close or break the exciting circuit, a special contact-breaker is employed,

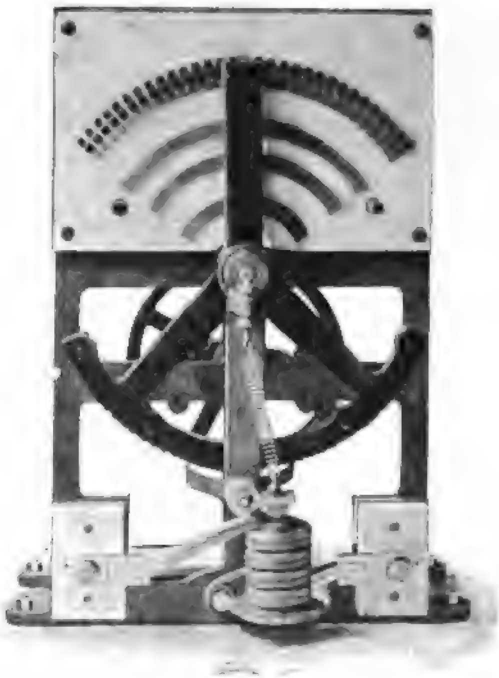

FIG. 22.—AUTOMATIC POWER-REGULATOR.

furnished with a series of studs connected to an auxiliary resistance.

The following is the sequence of phenomena in the balancing flywheel:—The circuit furnishes an electric current, of an intensity which is kept sensibly constant by means of an automatic energy-regulator (Fig. 22). Owing to this regulator, the intensity of the current given out by the primary station always corresponds to the mean power absorbed by the winding-motors. For this pur-

pose, the regulator works the exciting resistance of the dynamo, Z; this causes the voltage at the terminals of the motor, P, to vary, and accordingly regulates the speed of the entire buffer-group. On starting, the winding-motors absorb a very high current, the pressure of which passes from 0 to 1,000 volts. After starting, the intensity diminishes, the voltage remaining constant. As soon as the intensity of the current exceeds the normal value, or falls below the latter, the regulator automatically comes into play, and affects the excitation of the dynamo, Z. Its voltage will be either in the same direction with, or in opposition against, the circuit, and it diminishes or increases the voltage, and consequently the speed of the buffer-motor, P (Fig. 21). If the number of revolutions has been diminished, the flywheel gives off energy; the machine, P, is then no longer a motor supplied by the circuit—on the contrary, it works like a dynamo parallel to the circuit. Owing to this assistance, the current given off by the central station does not feel the shocks caused by the starting of the winding-motors. If the power temporarily required for winding does not reach the mean output of the central station, the automatic regulator reverses the excitation of the dynamo, Z, and thus increases the voltage and the number of revolutions of the buffer-appliance. The flywheel is thus accelerated, which absorbs the excess of energy, and the machine, P, runs as an electromotor. The variation of speed of the flywheel has been fixed, amounting to 30 per cent. When there is a long stop in winding, the buffer-motor in the first place causes an increase in velocity of the flywheel under the normal condition of the current; then, when its voltage has reached its maximum, the buffer-motor only withdraws from the circuit an amount of energy corresponding to that which it requires when running empty. In spite of the continuous variations of velocity, power and voltage, the brushes of the commutators remain fixed in the same position, and no sparks are produced at the commutators, the shunt-exciter being assisted by compensating poles forming a partial compounding. In order to stop the buffer-group, an electromagnetic brake acts by friction upon the rim of the flywheel. This brake comes into play automatically when any defect causes fusion of some intermediate part; at the same time, the circuit of an electric bell is closed, and thus attracts the attention of the engineer.

Operation of the Winding-engine.—By means of the principal working lever, the engineman, placed above in the upper shed (Fig. 16), can vary the direction of the intensity of the magnetic field of the dynamo, A, called the regulating dynamo, and thus at the same time the voltage supplied to the terminals of the two winding motors. As has already been said, the working apparatus also includes a commutator, which reverses the direction of the rotation of the winding motors. It is so arranged that, at the moment of commutation, the armatures of the motors shall be short-circuited, and in consequence no sparks can be produced. The working lever causes motion in one direction or the other, according as it is pushed upwards or downwards. The voltage is gradually increased, and in consequence the speed of the winding-motors is increased until it reaches the limit of 1,050 volts, and the speed of the rope reaches the rate of 26·25 feet (8 metres) per second. Every position of the lever accordingly corresponds with a definitely determined velocity.

Arrangements for Braking.—The engineman works a second lever with his left hand, which closes the circuit of a powerful electro-magnet for the brake, placed in a branch-circuit and thus absorbing but little energy. The brake is normally put on by a weight, which at the commencement of the lift is raised by the electro-magnet. The rods of the brake, of the depth-indicator, and of the working handle are mutually interlocked, and it is impossible for the engineman to loose them without having taken off the brake (Fig. 23).

Electrical Appliances for the Prevention of Overwinding.—The depth-indicator carries two arrows moving in opposite directions upon a graduated scale, from which the engineman can read off the position of the two cages travelling in the shaft. The depth-indicator is combined with an electric appliance to prevent overwinding. When the cage passes beyond the banking level, after the warning bell has rung, the principal working handle is automatically brought back to the position of stop; a little higher up the depth-indicator throws back automatically a subordinate lever, which frees the weight working the brake. At the same time, this subordinate lever liberates an

automatic stopping appliance, which cuts off the excitation of all the machines, and also stops the buffer-motor. It is to be noted that the electric anti-overwinder does not cut off the total current, but only the exciting current. The appliance is therefore of small dimensions and is not liable to injury due to arcs caused by breaking the current. If, in consequence of a sudden illness or through carelessness, the engineman leaves his working handle, the trip will be completed automatically, and at the end of the trip the above operation will stop the whole of

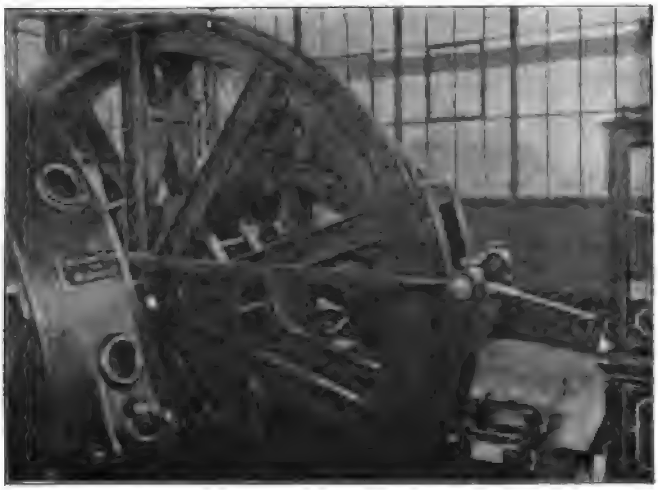

FIG. 23.—KOEPE-PULLEY AND ELECTRIC BRAKE.

the machines. It must be noted that, at the end of a trip, the engineman is compelled to reverse the direction of the winding-engine. A special catch prevents him from giving to his lever an impulse in the direction of the previous trip. Furthermore, for shaft-inspection an electro-magnet has been arranged, at the foot of the chief working handle, the armature of which locks the lever in such a way that it is absolutely impossible for the engineman to exceed the slow speed which has been prescribed.

Appliances.—In front of the engineman, a voltmeter with two deviations corresponds to the run in either direction, and an ammeter with two deviations marks the current that is doing the work of winding or acting on the brakes. On his left-hand

side, a Karlik tachygraph shows the speed for the time being of tho rope in metres per second, which is also marked automatically upon a self-registering drum by clockwork. The mode of action of the tachygraph is based upon the principle of centrifugal force. The shaft of the winding-engine transmits its movement by means of a pulley to a lyre-shaped piece having a central tube. This piece contains mercury, which rises or falls in accordance with the velocity of the engine. The change of level of the mercury in the central tube is registered by the tachygraph. The apparatus is combined with an electric alarm-bell, which rings for the engine-driver as soon as the velocity of the rope exceeds 13 feet (4 metres) or 26 feet (8 metres) respectively, according as persons or coals are being wound.

Supplementary Safety-appliance.—This safety-appliance has for its object:—(1) To cut off the current going from the circuit to the buffer-group when the intensity exceeds a certain value. The motors are thus protected against an excessive current, which might be caused, for example, by the cages jamming, by too sharp a start, etc. (2) To cut off the principal current when the cage goes beyond its prescribed limits. (3) To cut off the principal current when the exciting current fails.

The following is the mode in which these desiderata are obtained:—Whilst the buffer-machine is running normally its exciter is connected with the circuit. An exciting current traverses an automatic appliance, the bobbin of which is also connected with the circuit. The exciter of the buffer-machine is short-circuited, as soon as the bobbin of the minimum automatic cut-off is freed. Short-circuiting the field-magnets of the buffer-machine naturally produces in the armature a very great intensity of current; this affects the maximum automatic cut-off, which switches out the principal current. The accidents under the first heading have the following effect:—Too great an intensity of the current of the winding-motors works a relay situated close to the terminals of the buffer-dynamo. The armature of this relay closes the circuit of another relay having a retarded action, which (after a determined number of seconds) short-circuits the bobbin of the maximum automatic cut-off. This is thrown out, and closes upon itself the exciting circuit of the buffer-dynamo, as shown above. The employment of a relay with retarded action presents the following advantage:—This apparatus does not

break the circuit of the winding-motors for every momentary increase of current, but only when this dangerous increase of current persists during a number of seconds, for which the apparatus has been set.

Under the second heading, the depth-indicator works the switch for the end of the trip, which cuts off the exciter of the dynamos and of the electro-magnet of the brake. The minimum automatic cut-off then does its work. The switch for the end of the trip can be worked by hand by the engineman in case of imminent danger.

Under the third heading, any failure of the dynamos to excite would necessarily be accompanied by the unlocking of the minimum automatic cut-off; as in the previous hypothesis, the inductors of the buffer-dynamo would be short-circuited.

Mr. T. C. Futers (Broomhill) wrote that, whilst the description by Mr. Lozé of the electric winding-engines was no doubt interesting from the technical point of view of electrical engineering, he thought that the advisability of installing such plants was very questionable. So far, they appeared to have only been applied for main winding, to any extent, in connection with the Koepe system of winding, which in itself had many disadvantages, but was particularly suitable for electric winding. No doubt the placing of the winding-gear directly over the shaft reduced the expenditure of capital to some extent, but was this saving not more than swallowed up in the actual cost of the electric installation? He (Mr. Futers) thought that the question hinged on the point as to whether the adoption of electric winding would, by so reducing the amount of fuel consumed, more than cover the cost of maintenance, depreciation, and nevertheless yield a fair return upon the capital invested.

The question of purchasing current from an electric-supply company was certainly one that had some recommendations in its favour, but even for fairly small installations, electricity could be generated by a colliery-company at a cheaper rate than that at which it could be bought. On the other hand, if the supply-company took coal from the colliery-company at a fair price, one item might be set off against the other.

He (Mr. Futers) was surprised, on looking over the paper, at the amount of detail and separate mechanical and electrical

appliances for working and safeguarding the winding-plant that had ingeniously been thought out and applied to the various installations described, and these certainly must have added to the cost of the installations considerably compared with the smallness of the output with which they were separately capable of dealing. Comparing all this with a simple steam-engine, controlled and regulated by two simple levers: one controlling the steam admitted and the other the reversal of the engine, together with the importance of the operation of winding, the question whether it was worth while using electric winding-engines became a very serious one. A steam-engine might cost a little more for fuel, but it was simple in construction, reliable in its action, and would run for many years without costing anything for repairs; and it might be said that it was impossible to wear it out. Let the members contrast this with all the delicate switch-gear, electro-magnets, dash-pots and automatic mechanical and electrical appliances; and last, though not least, there was the risk of the bursting of the flywheel, even though by careful selection of material and construction it might be considered as very remote. It should be remembered that the flywheel was revolving at a high velocity, and that every time it was called upon to give out the energy that it had absorbed, which occurred every time that a cage was lifted, it received a shock, more or less as the winding was quicker or slower, which going on day after day would, in his (Mr. Futers') opinion, result in fatigue of the metal, and thus it might eventually fail, with results that could be better imagined than described. He (Mr. Futers) would have no hesitation in adopting electric winding for small auxiliary engines underground, or for every other operation about a colliery; and to put down a large generating-station at a colliery for the purpose of supplying current for general purposes would, without doubt, yield advantageous results. But, for main winding, he thought that the simplicity of the steam winding-engine was, and would remain, worth every penny of its extra cost in fuel; and it had yet to be proved that electrical winding was cheaper.

Mr. S. F. Walker (Bath) said that there appeared to be four points, which had to be satisfied by an electric winding-apparatus:—(1) Electrical winding must be cheaper than steam-winding; (2) the cage must be run at practically any speed

within certain wide limits; (3) the apparatus must be under absolute control; and (4) the plant must not make a big additional demand, at any instant, upon the central generating-station. The only winding-plant, which met the last point was the Siemens-Ilgner: the Ligny-les-Aire plant did so to a certain extent, but not so fully as the Siemens-Ilgner. The storage of the power in the flywheel tended to reduce the increased demand upon the generating-station when winding commenced. In the Siemens-Ilgner system and in the Westinghouse plant at the Lens colliery, the current passing to the motors driving the winding-drums was regulated in the usual way; but, while the Westinghouse plant had a simple regulation, without any attempt at economy, the regulation in the Siemens-Ilgner plant tended towards economy. The winding-plant at the Liévin and Ligny-les-Aire collieries had special systems of regulation, which were very ingenious in themselves. In each case, there were two motors turning the winding-drums, and the current from the generating-station was split between the two motors, just as it was split between the two motors of a tram-car. In addition, there was the motor-generator, taking current at 500 volts, and generating current from zero to 500 volts. This 500 volts could be put dead against the 500 volts of the regular service, and there would be no current passing through the winding-motors. The current generated by the generator of the motor-generator was then reduced and more current was conveyed to the motors: the motors then began to start, and winding began also. The current was then gradually reduced, until finally, at the last stage, the generator of the motor-generator was generating no current, and the 500 volts current was passing direct to the two motors. Then, the pressure which the motor-generator was creating was reversed and added to the live-current, and the current delivered at the terminals of the motors went on increasing up to 1,000 volts, and with it the speed at which the motors were running, the speed at which the winding-engines were running and the ropes were running, and so on. The arrangement was very ingenious, but it was also very complicated.

Prof. Henry Louis (Newcastle-upon-Tyne) asked, with regard to the sinking-engine at Liévin colliery, whether there was any possibility of danger when firing shots electrically with alter-

nating currents; and whether the induced current in the wires would be sufficient to fire a shot in the pit-bottom, without the wires being connected to the battery.

Mr. GERALD H. J. HOOGHWINKEL (London) wrote that the French installations reviewed were small and did not compare with powerful steam-winders. Their interest, however, depended upon the mounting of the winding-engine on the headgear and in the use of Koepe pulleys. The latter were especially adapted for electric driving, on account of smaller motors and lower first cost; also they reduced the revolving masses at starting and might be run at high speed.

As to Prof. Louis's remarks in regard to the effects of induction in cables for the sinking-shaft winding-engine described in Mr. Lozé's paper, he (Mr. Hooghwinkel) was not aware that any cables were necessitated at the pit-bottom; but, if they were, no danger was to be apprehended.

The CHAIRMAN (Mr. H. C. Peake) moved a vote of thanks to Mr. Ed. Lozé for his interesting paper.

Mr. S. F. WALKER seconded the resolution, which was cordially approved.

Mr. H. R. HEWITT (H.M. Inspector of Mines, Derby) moved a vote of thanks to the President and Council of the Geological Society, and to the President and Council of the Royal Astronomical Society for their kindness in granting the use of their rooms for the meeting; and to the owners of works to be visited during the course of the meeting.

Mr. W. C. BLACKETT seconded the motion, which was very cordially approved.

Mr. W. SAINT proposed a vote of thanks to Mr. H. C. Peake, Mr. J. S. Dixon and Mr. C. C. Leach for their services in the chair, during the course of the meeting.

Mr. S. F. WALKER seconded the motion, which was agreed to.

The following notes record some of the features of interest seen by visitors to works, etc., which were, by kind permission of the owners, open for inspection during the course of the meeting on June 1st, 2nd and 3rd, 1905:—

GREAT NORTHERN, PICCADILLY AND BROMPTON RAILWAY.

The Great Northern, Piccadilly and Brompton Railway is an amalgamation of the (1) Brompton and Piccadilly Circus Railway, which will extend from a physical junction with the Metropolitan District Railway, west of Earl's Court station, to Holborn at the upper end of the County Council's new street, where it forms a junction with the (2) Great Northern and Strand Railway to King's Cross and Finsbury Park. The Brompton and Piccadilly Circus Railway Act was passed in 1897, and the Great Northern and Strand in 1899, and they were amalgamated by Act of Parliament in 1902.

From its junction with the Metropolitan District Railway, this railway dips under the latter line and proceeds to South Kensington station, where an underground station will be provided below the present one; proceeding along the Fulham Road to its junction with the Brompton Road to the Brompton Road station, almost adjoining the Oratory; thence the railway proceeds up Brompton Road to a station at the upper end of Sloane Street; and along Knightsbridge to Hyde Park Corner, where a station will be provided adjoining St. George's Hospital. The railway then proceeds under Piccadilly to Piccadilly Circus, forming stations on its way in Down Street and Dover Street. At Piccadilly Circus, there will be a very large and convenient station for interchange with the Baker Street and Waterloo Railway, and the railway crosses below this line at a depth of 108 feet from the surface of the road. The railway then proceeds along Coventry Street to another interchange station with the Charing Cross, Euston and Hampstead Railway in Charing Cross Road, opposite the Hippodrome; thence under Long Acre, with a station adjoining Covent Garden, to Holborn, Russell Square, and under King's Cross Railway Station; thence proceeding under the Great Northern Railway as far as Finsbury Park.

The works were commenced in the early part of 1902, and are in operation throughout the whole length of the line, nearly the whole of the tunnelling having been completed. The ordinary Greathead shield was used at first, but after the works had been in progress for a short time an improvement was made on this by fixing an electrically-driven excavating-wheel at the face of the shield, thus obviating the necessity of the clay being excavated by hand to permit of the shield being pumped forward. This arrangement has proved very successful, and it has been used over the whole length of the line. With the original Greathead shield, the maximum number of rings completed in any week was about 40; but with the new rotary excavating-machine, 100 rings have been reached.

Access to the station-tunnels at Covent Garden is provided by two shafts, 23 feet in internal diameter, each containing two lifts in addition to a stairway-shaft, 18 feet in internal diameter. The lift-shafts are 112 feet in depth from the surface-station to the low-passage level. For service purposes, the shafts are carried down another 12 feet, from the bottom of which a service-heading, 10 feet in diameter, has been driven to the station-tunnels. This heading will subsequently be utilized as a ventilation-duct.

The southern station-tunnel has been completed, and in the northern station-tunnel a Greathead shield, 22 feet 10 inches in diameter, will be seen at work.

Westward, the running tunnels, 11 feet 8½ inches in diameter, have been completed for the full length of the line; and eastward, the running tunnels (enlarged to 12 feet 7 inches in internal diameter on account of the sharp curves) have now been driven as far as the Freemasons' Hall.

A short distance east of Covent Garden station, provision has been made for a cross-over road, consisting of a tunnel, 23 feet in internal diameter and about 100 feet in length.

Both the up and down tunnels have been driven through the impervious London or blue clay to the west of Great Queen Street, where the southern or down tunnel has now passed below the London clay and is in the Woolwich beds, consisting here of hard red and green mottled clays.

UNDERGROUND ELECTRIC RAILWAYS COMPANY OF LONDON, LIMITED: CHELSEA GENERATING-STATION.

The site comprizes 3·67 acres with a water-frontage on the river Thames and on Chelsea creek of 1,100 feet, and a frontage on Lots Road, Chelsea, of 824 feet (Figs. 1 and 2, Plate XXIII.).

The building is 453½ feet long, 175 feet wide and 140 feet in height from the ground-floor to the peak of the boiler-house roof. The office-building measures 81 feet in length and 25 feet in width, and has three floors, the lower of which forms the machine-shops. The main building has a self-supporting steel-frame, weighing about 6,000 tons. There are four chimneys, each 19 feet in internal diameter and 275 feet high; the foundations of the chimneys are 42 feet square and 34½ feet below the ground-floor level; and there are 2,200 cubic yards of concrete in each foundation. The electrical capacity of the building at normal-load is 57,000 kilowatts; and, on this basis, the cubic feet per kilowatt (including the office-building) are 139 and the square feet per kilowatt are 1·36. The steel-frame of the building is enclosed with brick and terra-cotta; the roof and all the floors are concrete, except the engine-room, which is floored with chequered steel-plates. In general details, the building is considered as a factory for the production of a commodity, and there are no ornamental features.

The south side of the building contains 64 water-tube boilers, arranged two stories high, and carried directly on the steel-frame of the building. Floor-space is available for 16 additional boilers. Each boiler has 5,212 square feet of heating-surface and 672 square feet of superheating-surface. The boilers are piped in groups of eight, each group supplying the steam for one electric generating-set and one feed-pump, there being no steam-connections between the several groups, except that a supplemental header at the eastern end of the building is connected to two groups. This header supplies the exciter-engines, air-compressors, house-pump, etc. The chain-grate stokers under each boiler have 83 square feet of surface. Economizers, with tubes 10 feet long and placed wider apart than is the usual practice, are grouped behind the boilers, with the customary bye-pass flues; 1,540 square feet of heating-surface are provided for each boiler. Boiler-feeders are placed on the ground-floor, and supply ring-mains on both of the boiler-room floors.

The main generating sets consist each of a horizontal turbine-engine running at 1,000 revolutions per minute, and a three-phase generator wound for 11,000 volts and 33⅓ cycles. There are eight such sets, with floor-space for two more of the same size, and one of half the size. The normal rating of each generator is 5,500 kilowatts, but they will carry an overload of 50 per cent. for 2 hours, at practically the same steam-consumption per kilowatt-hour. There are four 125 kilowatts 125 volts steam-driven exciter-sets running at 375 revolutions per minute.

The condensing system consists of vertical condensers, each with 15,000 square feet of cooling surface, located in pits between the engine-foundations. The circulating water is supplied by pipes, 66 inches in diameter, laid to the edge of the channel of the Thames. Each condenser has a centrifugal pump, 20 inches in diameter; the duty of this pump is simply to overcome the friction of the pipes, as the system is arranged on the syphonic principle, the top of the condensers being within 29 feet of minimum low tide, and the circuit is closed. The intake and discharge-mains are arranged for reversible flow. The condensers are designed to work on the dry-vacuum principle, the air-pump and the water-pump being separate. All the condenser-pumps are driven by induction-motors.

The switch-board is carried on three gallery-floors, extending across the north side of the engine-room with returns across the eastern end. All high-tension switches are motor-operated, and the feeder-system extending to the 23 sub-stations is in duplicate. A line of 64 ducts is constructed to carry these feeders to the nearest point on the Metropolitan District Railway at Earl's Court.

Coal is received on lighters in a tidal basin at the eastern end of the station, or by rail at an unloading point of the West London Extension Railway on the opposite side of Chelsea creek. For unloading barge-coal, the basin is spanned by two travelling cranes, each working a grab lifting 1⅓ tons. The coal is weighed in the tower at one end of each of these cranes, dropped on to a belt-conveyor, and carried thence by duplicate inclined elevators, 140 feet high, to the top of the building. Rail-borne coal will be taken from a hopper under the coal-wagons by an inclined elevator to the top of the building at the opposite end. The distribution over the bunkers is effected by duplicate belt-con-

veyors, arranged so that the direction of travel of both belts can be reversed so as to handle coal coming in at either end. The storage-capacity of the bunkers is 15,000 tons. The daily consumption will reach 800 tons, and six of the largest river-barges can be placed in the basin at each tide.

Ashes are removed by an industrial railway worked by a storage-battery locomotive; two lines of rails are laid under the ash-hoppers on the ground-floor. The ashes drop into self-dumping skips, to be unloaded into barges by pneumatic hoists on the dock-wall at the western end of the premises, or stored in an adjoining bin if no barge is available.

The capstans, barge-basin gate mechanism, and many of the large valves in the building are worked by pneumatic motors.

The electric motors on the travelling cranes over the engines, as well as those on the oil-switches, are driven by direct-current at 125 volts. All other motors are worked by three-phase current at 220 volts, and most of the lighting is placed on the latter circuit.

THE MIDLAND COUNTIES INSTITUTION OF ENGINEERS.

EXCURSION MEETING,
MAY 2ND, 1905.

The members visited Messrs. James Oakes & Company's collieries, brickworks and pipeworks, Riddings, Alfreton.

The SECRETARY announced the election of the following gentlemen:—

MEMBERS—

Mr. W. ASHTON-HOCKLY, Manager, Bhaga Colliery, Jharrigha Coal Company, P.O., Jharrigha District, Manbhoom, India.

Mr. WILLIAM HERBERT GOODWIN, Mining Engineer, Swanwick Collieries, Alfreton, Derby.

Mr. ALBERT EDWARD LOOS, Electrical Engineer, Derbyshire and Nottinghamshire Supply Company, Power-station, Ilkeston.

ASSOCIATE MEMBERS—

Mr. JAMES MORTON GOODRICH, Manager, Bleak House, Ilkeston.

Mr. HENRY ARCHIBALD SANDERS, Somersall Hall, Chesterfield.

ASSOCIATES—

Mr. WILLIAM BECKETT, Under-manager, 16 Drummond Road, Ilkeston.

Mr. JOHN SPENCER, Mechanical Engineer, Half-way, Sheffield.

STUDENTS—

Mr. FREDERICK JAMES DURANCE, Student of Mining Engineering, Manners Colliery, Ilkeston.

Mr. THOMAS KENNETH KNOX, Pupil, The Cliff, Cinder Hill, Nottingham.

Mr. LEONARD COLBORN STEVENS, Mining Student, South Leicestershire Colliery, Coalville.

Mr. WILLIAM CULLEN WILKINSON, Student of Mining Engineering, Manners Colliery, Ilkeston.

THE SOUTH STAFFORDSHIRE AND EAST WORCESTERSHIRE INSTITUTE OF MINING ENGINEERS.

GENERAL MEETING,

HELD AT THE UNIVERSITY, BIRMINGHAM, JUNE 5TH, 1905.

PROF. R. A. S. REDMAYNE IN THE CHAIR.

A vote of condolence was moved to the family of the late Mr. T. O. Langstaff.

The minutes of the last General Meeting and of Council Meetings were read and confirmed.

The following gentlemen were elected:—

MEMBERS—

Mr. R. R. CAME, Mining Engineer, Woodhall Spa, Lincolnshire.
Mr. M. W. WATERHOUSE, Mining Engineer, Bedworth.
Mr. P. S. JOHNSON, Mechanical Engineer, Birmingham.

Mr. HENRY JOHNSON proposed that the name of the Institute be altered to the "South Staffordshire and Warwickshire Institute of Mining Engineers."

Prof. R. A. S. REDMAYNE seconded the resolution.

The resolution was carried unanimously.

DISCUSSION OF MR. L. HOLLAND'S PAPER ON THE "PROBLEMS OF WORKING THICK COAL IN DEEP MINES,"* AND MR. E. O. FORSTER BROWN'S PAPER ON "A METHOD OF PACKING EXCAVATIONS IN COAL-SEAMS BY MEANS OF WATER."†

Prof. R. A. S. REDMAYNE said that this method of packing the goaf appeared to be peculiarly suitable to the conditions of

* *Trans. Inst. M. E.*, 1905, vol. xxviii., page 349.

† *Ibid.*, 1904, vol. xxviii., page 325; and 1905, vol. xxix., page 3.

mining at some of the South Staffordshire collieries; where there was trouble from gob-fires, subsidence, etc. He had recently seen some samples of coal taken in South Staffordshire and in the North of England some years ago, and since exposed to atmospheric influences indoors. These samples showed very distinctly the different physical structure of the coals from the two different coal-fields, and the manner in which they had, relatively, been acted on by the air. The coal from South Staffordshire had fallen away to the consistency of earth. It would appear that most of the South Staffordshire coals had a sponge-like capacity for absorbing oxygen, while the coal from the North of England had remained practically unaltered. When examining these samples, he (Prof. Redmayne) could not help thinking that microscopic examination of the structure of coal would help them greatly in solving the problem of spontaneous combustion, as he thought that the texture of the coal had an important bearing on the question.

Mr. F. G. Meachem mentioned that the troubles at Hamstead colliery were due to a combination of mechanical and chemical actions peculiar to that pit.

Mr. E. H. Roberton said that the difficulties due to temperature would vary considerably with the difference in the heat conductivity of the surrounding strata, and would be the ultimate deciding factor when it came to the question of the abandonment of a mine. The working of thick coal at great depths would, in comparison with thinner seams, be more subject to the difficulties arising from this factor. Sir Joseph Prestwich had recently shewn that the absolute thermal resistance of coal varied from 787 (cannel) to 1,470 (Newcastle steam coal), while that of Coal-measure shale was 425; and of sandstone, 398 if dry, and only 166 if wet. The thermal resistance of a dry seam of coal was, consequently, about 3½ times as great as that of Coal-measure shale or dry sandstone, and 9 times that of wet sandstone. A coal-seam of considerable thickness would, therefore, afford a much greater opportunity for the accumulation of heat in its midst than a thin seam, no part of which was far distant from strata of comparatively low resistance to heat-conduction. The danger of gob-fires was obviously more imminent in a deep pit, where there

was already in the strata a naturally high temperature, as the activity with which oxygen was absorbed increased as the temperature increased, and so a cumulative process was initiated, and it might develop into fire unless the heat was carried away before too high a temperature was attained.

Prof. R. A. S. REDMAYNE did not think that the thickness of a coal-seam had much effect in increasing the temperature and the risk of spontaneous combustion, but this effect was due rather to the conductivity of the surrounding rocks and the mechanical and chemical actions induced.

Mr. W. N. ATKINSON observed that the causes of gob-fires were not clearly understood, and of the great number of causes mentioned only a very few could be universally applied. No one could pretend to say from an examination, whether any given coal was liable to fire spontaneously. He (Mr. Atkinson) thought that underground fires in South Staffordshire coal-mines might sometimes be caused by the candles and open lamps, which were very freely used in thick-coal pits. Further research into the causes of gob-fires was required, in order to find the predominating factors, and, if possible, to enable any particular seam of coal to be pointed out as liable to spontaneous combustion.

Mr. P. NEVILLE suggested that an increase in the inclination might increase the liability of a coal-seam to spontaneous combustion. In a seam, 1,650 feet deep, at Walsall Wood colliery, on one side of the shaft, with an inclination of 1 in 6, fires were unknown; while on the other side, where the inclination was 1 in 12, fires had occurred.

Mr. L. HOLLAND approved of the suggestion, that a series of experiments should be carried out so as to arrive at the cause of some seams being more liable to spontaneous combustion than others. There could be no doubt that the nature of the coal played an important part in the cause of spontaneous combustion: thus certain beds composing the Thick coal-seam were more liable than others. Fires were frequently found to occur in the Brazils and the White coal. The Brooch coal-seam was entirely different in nature from these coals, and it would not take fire if worked at a depth of 3,000 feet. Some coals contained more hygroscopic moisture than others, and as coal became heated by

oxidation, the moisture had a tendency to expand and disintegrate the coal, and thus offer so much greater surface for oxidation. This might account for pieces of the Thick coal-seam crumbling to dust when kept for any length of time. In driving out a pair of roads in the Thick coal-seam, the liability to fire was diminished by driving the bolt-holes from the intake-airway to the return-airway further apart. Thus, if they were driven 300 feet apart, instead of 150 feet, the danger would be reduced 50 per cent., because fires frequently occurred in bolt-holes after they had been standing for some time; breaks occurred along the sides of the road, and when brick-stoppings were put across the road the air pulled through the small breaks and caused fires. The bolt-holes need not be driven oftener than 600 feet apart, if small electrically-driven fans were used to ventilate the headings.

He (Mr. Holland) did not think that sluice-packing could be satisfactorily applied to the Thick coal-seam, where it was flat, because of the difficulty of filling up the top section, and of keeping the water in the opening. The batt under the Thick coal-seam was generally very porous, and would carry the water along the haulage-roads and into other places where it would not be desired, and would become a source of great expense. He had had experience of working a Thick coal-seam, dipping about 1 in 4 or 5, and found that water alone formed a good packing-material and had saved ribs of coal being left as a protection against fire in the back openings, as the workings came back up the dip.

Mr. W. N. Atkinson thought that the conditions at the mines where sluice-packing had been tried were very similar to those existing in South Staffordshire, and the objects to be obtained by such packing were practically the same. It appeared to him well worth consideration as to whether this system could not be applied to South Staffordshire. The cost of 6d. per ton of coal won by the process did not appear to be prohibitive, and considerable advantages might accrue from its adoption, which would more than make up for such cost. In a district like South Staffordshire, the output could be considerably increased, as the greater efficiency of the packing by this system would permit of the working of numerous pillars, which had to be

left for the protection of buildings, as the surface would not be lowered to any appreciable extent. Sand appeared to be the most suitable material for packing, but that was only of advantage locally where sand could be found. It was a question whether spoil-heaps would not serve the purpose, but that depended upon their nature. The removal of those spoil-heaps, however, would be of great advantage to the district. Mr. Holland had pointed out that the method could not be suitably applied in flat seams, but he (Mr. Atkinson) thought the difficulties would be overcome by the erection of temporary dams, by which the débris would be retained until the water had drained away and the material had solidified, and then the dams could be removed and erected elsewhere.

Mr. J. T. ONIONS said that the new method of packing the goaf had not been tried, to his knowledge, in any British colliery. One of the greatest difficulties in that district was the provision of a suitable material, but, as Mr. Atkinson had suggested, spoil-heaps might be utilized and, if necessary, the material could be crushed down to the size best adapted for use; granulated blast-furnace slags had been used at one colliery. He thought that the water flowing over the roads, when leaving the dams, would be likely to injure them.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
APRIL 11TH, 1905.

MR. JOHN GERRARD, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. P. B. COULSTON, Mechanical and Electrical Engineer, 5, Cross Street, Manchester.

Mr. REUBEN H. HARVEY, Electrical and Mechanical Engineer, Anchor Cable Company, Leigh, Lancashire.

Mr. THOMAS SCHOLES, Colliery Manager, Oswaldtwistle Collieries, Oswaldtwistle, Accrington.

Mr. JOHN WALSHAW, Colliery Manager, Astley and Tyldesley Collieries, Tyldesley, Manchester.

CAPPING OF WIRE-ROPES.

The PRESIDENT (Mr. John Gerrard) exhibited a solid form of wire-rope capping, cut across so as to shew a sectional view of the wires embedded in a composition of white metal. He desired to call the attention of the members to the serious difference which was frequently found between the strength of wire-ropes and their cappings. He mentioned the question now, so that it might be considered, and at a subsequent meeting the members might give their experiences and express their views on the subject. The capping of ropes, for some years, had received his (Mr. Gerrard's) consideration, and it was alarming to find that there was such a difference between the strength of the cap and the strength of the rope, in a great many of the cappings in use. The loss of strength was as great as 50 per cent., that was to say, there was often a factor of safety of 10 to 1 in the rope and of only 5 to 1 in the capping. As

the strength of a chain was that of its weakest link, so the strength of a winding-rope was no more than the strength of its capping. Mr. F. L. Ward, mining engineer of the Bradford colliery, had given much attention to the question of improving the form of the cap; and, as the result of long-continued experiments, he had succeeded in making a cap which was equal in strength to the rope.

DISCUSSION OF MR. J. ASHWORTH'S "NOTES ON THE CROW'S NEST COAL-FIELD, BRITISH COLUMBIA."*

Mr. JAMES ASHWORTH, replying to Mr. Joseph Dickinson, wrote that the coal-seam at Frank is practically vertical above the adit-level, and the mode of working is a mixture of longwall and pillar. Two rows of pillars separate the rooms, which are possibly 180 feet wide, and are kept full of mined coal, and only as much coal is taken out by shoots into the pit-wagons at the foot of each room, as is necessary to allow room for working. The men reach the working-faces by manways in the pillars between the rooms, and these pillars are the real supports of the wastes, together with the loose coal.

It seemed probable that the masses of rock pressing against the unsupported vertical side of the coal-seam, caused it to bend or break and thus, so to speak, loosened the sprag, which held up the mountain-side. If this took place, it is conceivable that the effect on the mine would be as described by the men who escaped, and the noise, within the mine, might only be equal to that of a muffled and heavy weighting of the roof, as experienced in a thick mine of a flat or moderate inclination. Some of the rooms were worked within a short distance of the outcrop, and the strata were sufficiently soft for the men to work their way out without much difficulty.

Mr. ARTHUR ROSS read the following paper on "The Circulation of Water in Steam-boilers":—

* *Trans. Inst. M. E.*, 1904, vol. xxix., page 330.

THE CIRCULATION OF WATER IN STEAM-BOILERS.

BY ARTHUR ROSS.

For at least the last 100 years, the circulation of water in steam-boilers has engaged the attention of engineers and boiler-makers, yet the accumulated knowledge of these years has still left plenty of room for additions to the stock of information, although boiler-design has varied almost to bewilderment. Mr. N. P. Hugh, in *A Treatise on Boilers*, remarks that, up to 1873, there were no less than 3,000 patents for steam-boilers, and doubtless since that date some thousands of additional applications have been filed.

Boilers are naturally listed for all practical purposes under two main types, namely, (1) fire-tube, having fire inside the tube; and (2) water-tube, having water inside the tube. The opinions of experts still differ so widely, each side having so many good arguments for the defence of their particular type, that the writer does not propose to discuss the merits or shortcomings of any boiler in particular, but rather to exhibit some details touching the question of circulation, which is more or less common to every type of boiler.

Engineers agree that an efficient circulation means a greater efficiency of the steam-generator, and to this conclusion they are led by the natural movements which follow the application of heat to a fluid or gas, and possibly solids also.* Water follows the almost universal law that the absorption of heat expands a body and after expansion it will weigh less per unit of volume. In other words, each unit is lighter, in proportion to the heat absorbed, and the warm molecules of water rise, by virtue of their lower specific gravity, thus making room for the heavier and colder molecules to fall and touch the source of heat, till they too, having taken in as much as makes them appreciably lighter than the upper particles, also want to reach the top.

* These movements are termed "convection-currents."

This movement is the result of under firing, but should the heat be applied at the top it would take a very long time to raise the temperature of the lower water, and even then it would mainly be done by conduction through the outside shell. The warm molecules once on the top have no inclination to vacate that position voluntarily (Fig. 1, Plate XXIV.). Exactly opposite effects result from opposite treatment, and by applying cold to the upper layer of water, convection-currents are started downward, the result of their greater specific gravity (Fig. 2, Plate XXIV.).

Figs. 1 and 2 (Plate XXIV.) represent two copper vessels, *a*, similar in all respects, except that one is surrounded by a gas-ring, *d*, and the other by a freezing mixture, *e*. On watching the thermometers, *b* and *c*, the temperature will rise rapidly at the top thermometer, *c*, of the heated tube (Fig. 1) while the lower one, *b*, keeps stationary. The effect of the freezing mixture will be demonstrated by the fall of temperature at the bottom thermometer, *b*, till 40° Fahr. is attained, and then the thermometer, *c*, will take up the running and the temperature fall, while the bottom thermometer, *b*, remains stationary.

The writer will presently show how these facts bear upon steam-boilers, but in nature they are of the utmost importance. For instance, although by the waves of the sea, the tides, and the flow of rivers, considerable heat is absorbed from the sun, yet, if heat were conducted rapidly downward, it would probably kill all aquatic organisms; while, on the other hand, if cold were allowed to have continued sway, then by convection-currents, cold water would descend, and ice would first form at the bottom. As heat convection-currents will only rise, then open waters would always remain frozen at the bottom, until finally there would be a return of the ice age. The expansion of water is an exception to the rule, since water attains its greatest density and minimum volume about 40° Fahr., so that still colder water, between 40° and 32° Fahr., floats on the surface instead of falling to the bottom, and ice is formed on the surface instead of at the bottom. These natural currents cease to act when the water is nearly of an even temperature throughout: for instance, a general ebullition of steam kills all other movement; then there is plenty of disturbance, but no circulation of water over the heating surfaces.

Convection-currents, therefore (useful though they be), cannot alone be depended upon for efficient circulation. Even in the old under-fired boiler, when steam is formed, there is an end to all true circulation; and, if the water is heated above the bottom, as in Lancashire and Scotch boilers, the warm convection-currents will not move downward, as every observer of the temperatures at the bottom, when lighting up, is fully aware.*

As convection-currents are always slow and weak, failing to operate when aggressive steam-bubbles appear, one must ascertain whether it is not possible to obtain the desired circulation in some other way. In this case, as in all other operations of any kind whatever, nothing can be done except by the expenditure of work or its equivalent in heat. Even convection-currents obey this rule, as the warm current on rising loses heat, until the whole of the water attains an equal temperature. Hence, the operation must be conducted in such a manner that the profit is a large one; some work must be spent to gain greater heat, otherwise it is outside the realms of practical consideration.

Let it be understood that by efficient or real circulation, is meant a movement of the water over the heating surface of the boiler. Other movements or disturbances there may be; but such a flow is only of value when it tends to absorb more of the provided heat of the fire; and other movements may even have a wasteful effect, unless carefully guarded.

It is not necessary to demonstrate the advantages of a moderate circulation of the water over the heating surface, as there cannot be two opinions on this point, although there are differences of opinion as to the value of a high rate of movement. Some experiments seem to show that, after a critical speed is reached, there is a rapid fall in efficiency; † and the writer hopes to investigate this point at an early date.

To imagine the operation of steam-formation, one must con-

* *Manchester Steam Users' Association: Report on a Series of Red-hot Furnace Crown Experiments, to ascertain the Result of Injecting the Feed-water into a Boiler when short of Water and with Fires burning*, by the Chief Engineer, Mr. Lavington E. Fletcher, 1890, pages 48 to 50.

† "Experiments on the Heat-absorption Power of Water," by Mr. George Halliday, *Transactions of the Institute of Marine Engineers*, London, 1899, vol. xi., No. 84 paper, page 17.

sider a particle of water, which occupies only a very small volume: on absorbing sufficient heat, it is turned into steam and occupies many times its original volume, varied according to the steam-pressure, until it becomes large enough to overcome the pressure of the layers of water above it. The disturbance that it causes at the place of generation is very small: the greatest movement occurs in the upper layers of water; but these layers do not lie on the heating surface, and, as shewn in Fig. 1, (Plate XXIV.) they do not flow downward. Consequently, they do not assist in a real circulation. The physical changes, occurring when water leaves the fluid for the gaseous state, are still shrouded in mystery; and it may be that, when a workable theory of this wonderful change is propounded, one will know better how to make water absorb heat, and to build boilers accordingly. At present, it is known that the change does take place, but by no means free of cost. Were it not for the marvellous energy stored up in steam, it would be useless for present applications; and it is this heat-absorbing capacity which one must nurse and feed, for, by the proportion of heat that can be transferred from the fuel to the water, the efficiency or otherwise of the steam-generator will be judged.

Fig. 3 (Plate XXIV.) represents two vertical glass tubes, *a* and *b*, $\frac{3}{4}$ inch in diameter, connected at their bases, by a copper tube, *c*, and attached at their upper ends to a tank, *d*. Fig. 4 (Plate XXIV.) is a single glass tube, *a*, 2 inches in diameter, the base being closed by a copper cap, *b*, and heat is applied from a gas-ring, *c*. From experiments with these appliances, the writer draws the following conclusions:—

(1) A small quantity of water placed in the single tube (Fig. 4) will demonstrate how steam frees itself under atmospheric pressure, when the layer of water on the heating surface is thin.

(2) The layer of water being increased in depth, it is evident that the steam has more difficulty in shaking off the superincumbent weight of water. The conclusion to be deduced from this fact is that, having once produced the bubble of steam, one must not hinder it from getting free of the covering water, and no possible advantage can be derived by opposing the natural action of the steam to free itself: it is wanted for use, and it should be afforded as easy a passage as possible. This experiment seems to indicate that the Lancashire type is prefer-

able, on this point, say, to a Belleville boiler, as the water over the crown of the furnace of a Lancashire boiler is generally less than 1 foot deep; while in a Belleville boiler the steam-bubble must traverse 100 to 160 feet of pipes before it is free. The writer does not think that the necessity for allowing steam to shake off the water, as quickly as possible, has been realized by the later designers of boilers. A bubble of steam cannot squeeze through 10, 20 or more feet of water, without losing some energy, a loss which does no useful work.

(3) As steam is formed in the double tube (Fig. 3), a reciprocating motion will be produced, governed by the formation, condensation or discharge of steam at the base. Some such action is likely to ensue when the tube-ends are not covered with water, as in the case of some types of boilers. It will also be noticed that the steam-bubbles form plugs, easily in the small tube (Fig. 3), but not so easily in the large tube (Fig. 4); though doubtless there would be a similar action in a large tube, if sufficient fire were applied. It may also be noted that the plugs of steam do not "entrain" the water as has so frequently been described; the action is rather a slipping of the steam past the water, the large tube (Fig. 4) clearly demonstrating the same action. Steam does not carry the water along, although it might blow out a small quantity at the tube-end: the bubble elbows itself into a front place, just as a constable forcing himself to the front through a tightly-packed crowd. Taking any particular section of water, it seems to remain continually in about the same position, while steam is being regularly formed.

(4) When the double tube (Fig. 3) is filled with water, circulation is set up; and it is noticeable that, although the bulk added is but small yet the radiation of heat, by circulation, is so great that it will take a long time to bring the water to the boil, and even then ebullition will not be so rapid. This lesson proves that radiation must be checked to the greatest possible extent; and although the correctness of Newton's law that "the transmission of heat is in direct proportion to the difference in temperature," is being largely questioned, so far as the absorbtion of heat by water is concerned; yet there can be no possible doubt that heat falls out of carefully-made steam very rapidly and upon every possible occasion.

Figs. 5 and 6 (Plate XXIV.) represent a model of an ordinary Lancashire boiler, heated with gas-fuel. The tubes, *a* and *b*, the smoke-box, *c*, the chimney, *d*, and the enclosing-case, *f*, are made of copper; and the boiler-shell is made of glass. This model demonstrates how steam-bubbles leave the furnace-tubes, and, at the same time, the position on the tubes, from which they rise, can be noted.

Fig. 7 (Plate XXIV.) illustrates the apparatus used in an experiment intended to show the flow of circulation, and to demonstrate the possibility of dry tubes, when the fire is at its highest. This model of a water-tube boiler consists of two vertical glass tubes, *a* and *c*, connected by an inclined copper tube, *b*, and attached to the tank, *d*. The experiment tends to demonstrate that downcomers and risers should, at least, be of equal capacity with the steaming tubes and that a slight constriction, in either the inlet or the outlet, may be bad for the tubes. If it is not possible to provide a corresponding down tube for each uptake tube, then the capacity of the downcomer should be equal to the sum of the volumes of all the uptake tubes. Even this precaution will not entirely obviate the trouble when boilers are forced, but the liability to serious damage is not so great, as the dryness of the tube is momentary; while, with a constricted end, the pipe may be dry for an appreciable period. During the time that steam fills the tube no circulation is possible, and a careful watching of the model will demonstrate this at once.

Mr. J. I. Thornycroft stated, some years ago, in his paper on the "Circulation in the Thornycroft Water-tube Boiler," that "I have recently made experiments on the relative circulation of boilers when the generating tubes deliver above the water in the separator and below it, and I have found that, in the case where they deliver above, the circulation is rather more than double that when they deliver below."* The arrangement suggested by Mr. Thornycroft, for delivering the generating tubes above the water-level is a good one, as it offers little or no hindrance to, but rather acts as a suction upon, the return-supply; and it is more likely to create a real circulation of the

* *Transactions of the Institution of Naval Architects*, 1894, vol. xxxv., page 289.

water, than in boilers where the steam is constantly struggling to overcome the head of water in the top drum: this being the case in several types of boilers. This model also shows that convection-currents can be utilized, so that the natural movement is aided and maintained. Messrs. Yarrow & Company's experiments* showed that the addition of heat increased the rate of flow.

The tubular models therefore demonstrate that:—

(1) It is possible to raise the speed of the circulation by enclosing and guiding the natural convection-currents.

(2) The upflow and return tubes should be made of equal size.

(3) There is considerable danger of restricting the upflow or return, either by using smaller tubes or by the deposition of scale.

(4) It is a question whether the long distance through which the bubbles of steam have to travel is not a disadvantage.

(5) Although the circulation may be rapid, yet as the tubes are partly (or at times wholly) full of steam, they are then not so efficient as when full of water, because a gas is a worse conductor of heat than a fluid; and steam will absorb less heat from the fire. Hence, all possible efforts should be made to keep the water, as solid as possible, upon the heating surfaces.

(6) To obtain the very highest results, water must always be solid over the heating surfaces, and the layer of water should be thin, so as to allow of the free egress of the steam.

It may be asked, if circulation be so very important and valuable, and seeing that water-tubes seem to provide the most suitable form, why they are not used to the exclusion of all others. To reply fully to this question rather takes us outside the subject of this paper, but a few remarks may be made: (1) As soon as the strictest simplicity of design is departed from, there always arises a great array of structural troubles, and boilers are no exception to this rule. To the purchaser this means a considerable annual charge, either for repairs or for extra labour in cleaning, joint-making, etc. (2) The question of large brick-furnaces is a serious one, both from the standpoint of

* *Engineering*, 1896, vol. lxi., page 39.

maintenance and that of efficiency as compared with a water-surrounded furnace. And (3) the point arises, whether flames or gases, striking outside a tube full of water, have as efficient heating effect as a tube full of flame wholly immersed in water. These considerations weigh less heavily in cases where space and weight are not of such vital importance as in torpedo-boats, and the like. Under the usual industrial conditions, the evaporation per pound of fuel is much the same in the large tube-type and in Lancashire boilers; and it is probable that the great gain, obtained by rapid circulation, is largely lost in the extensive brick-furnace, which has to be kept at a great heat, and the greater ease with which gases escape round the outside of a tube, without parting with their heat.

In boilers of the Lancashire type, the principal source of heat is surrounded by water, instead of surrounding the water, as in a water-tube boiler; the bulk of water is considerable, the layer of water above the fires is fairly thin, and the highest efficient heating surface is comparatively small. Yet the evaporating effect of a Lancashire boiler is equivalent to that of a water-tube boiler per pound of fuel. This result is probably due mainly to the ease with which the steam can be set free from the water, the heating surface is never dry, and the fact that the fire is water-jacketed; and not because the Lancashire boiler has any superiority in circulation, for after steam is formed, even when the boiler has cross-tubes, the circulation below the firebox-level is negligible. The same action goes on as in a tube: a bubble of steam, once evolved, is in a hurry to join the other free steam and rushes to the surface, not lending the heavy water any assistance to rise, but rather treading it down to the best of its ability. In this way, the upper half of the furnace-tubes have steam rising from them, while the water surrounding the lower half is dead. This is demonstrated by the greater accumulation of scale, as well as its character, upon the upper half; and when corrosion, from bad water, takes place, evidences of it will be first found at and below the level of the fire-bars, while often the upper surfaces of the furnace and of the shell are perfectly sound: the dead-water at the bottom becoming denser and fuller of impurities every hour.

Bad circulation also adds to the stresses and strains to which a cylindrical boiler is subjected, as the temperatures vary greatly

in different parts.* These unequal strains are, indeed, responsible for nearly all the troubles of leaky seams, grooving, etc., common to cylindrical boilers.

The movements on the water-surface of a Lancashire boiler are from front to back, added to a cross action either from both sides to the centre, or from the middle outwards to the sides. The greatest disturbance and most rapid formation of steam occur over the fires, and just near the bridge; beyond the bridge the temperature rapidly falls, and less steam is generated. It is doubtful, after a layer of soot is deposited, whether much steam is formed at the sides of shell, and the bottom-flue may even steal some heat from the boiler, if the gases are allowed to become too cool: that is, the temperature becomes insufficient to overcome the insulation due to the boiler-plate *plus* the steam-temperature. Consequently, with rising pressures, there should be a corresponding rise in the flue-temperature.

Numerous attempts have been made to induce circulation in cylindrical boilers. Various kinds of baffles have been used, but they failed, because, as already shewn, the warm convection-currents obstinately refused to move downward into the colder zones. Various kinds of hoods, cones and cross-tubes (large and small, and round and straight) have also been tried; but they failed, because the column of water in them does not remain solid after steam begins to form. They then act very much like the bottom tube in a forced-draught water-tube boiler, being filled with rapidly-generated steam and blowing out the water. The steam in contact with the fire is then a source of loss rather than of gain, as it does not extract so much heat from the fire as water. They all fail as water-circulators so soon as the column of water is broken by steam, even if, before that time, they have been effectual. The general result of their use is destruction of the cross-tubes, and a lowering of the boiler-efficiency.

It is very difficult to illustrate this action in the model, but the following experiment will show the writer's meaning. In the glass tube, *a* (Fig. 4, Plate XXIV.), the rise of steam-bubbles is visible, and illustrates the formation of steam above the heat-

* *Manchester Steam Users' Association: Report on a Series of Red-hot Furnace Crown Experiments, to ascertain the Result of Injecting the Feed-water into a Boiler when short of Water and with Fires burning*, by the Chief Engineer, Mr. Lavington E. Fletcher, 1890, pages 48 to 50.

ing line (in this case, the gas-ring, *c*), for instance, the fire-bar level in a cylindrical boiler. Below the fire-level, there is not a deep disturbance, and the heat is only carried downward by the sides of the vessel.

Mechanical circulators of the water have been used. Mr. H. W. Harman, in 1859, used a screw-propeller, working at the bottom and back-end of the boiler, and actuated by a spindle passing through the boiler-shell at the top.*

Recognizing the difficulties of maintaining a solid column of circulating water and the importance of keeping the boiler-water in motion, the writer has introduced the Hotchkiss automatic circulator, which deals with the water only (see Appendix). It avails itself of the convection-currents induced when the boiler-fire is lighted, and the movement of the water is maintained with a very slight loss of heat by radiation. It takes the hottest water from over the furnaces and delivers it along the bottom of the boiler. In this manner, the heat is more evenly distributed and the lower layers of water are kept in motion, compelling a general movement of water all over the boiler. There does not appear to be any fear of over-circulation by this type of apparatus, because solid water alone is moved, and this compels a large body of water to continually brush over the heating surface. With this apparatus, cylindrical boilers can be pushed without fear, and kept standing under large fires without inducing undue stresses. This is due to the temperature-equalizing tendency of this kind of circulation, resulting in an almost equal expansion of the top and of the bottom of the boiler. As convection-currents are the primary movers, it is not surprising to learn that this circulator starts automatically, and maintains the flow continuously until the boiler returns to the temperature of the surrounding air. Hence, when the fires are banked, there is still a distribution of heat going on from the top to the bottom, and whether the boiler is working or standing, lighting up or cooling down, there is a constant interchange of water from above to below the furnaces.

Probably, few boiler-owners consider the extremes of temperature to which a boiler is subjected. The temperature of the fire ordinarily averages 2,500° Fahr. to 3,000° Fahr. Sometimes, the last flue has a temperature between 300° and 400° Fahr., a

* British patent, 1859, No. 1909.

fall of 2,200° to 2,600°. The inside temperature of the boiler, being that of the steam, is anywhere between 212° and 400° Fahr., there is thus a great strain through differing heats on the two skins of the boiler-plate; and, while the heat has a free passage and is not stored in the plate itself, no harm is done. Knowing the great difference between the temperature of the fire and of the gases in the last flues, it is not surprising to learn that the circulation at the bottom of a Lancashire or Cornish boiler is either very dull or non-existing, the heat in the flue being barely sufficient to maintain the water at steaming temperature, much less make steam; and great differences of temperature will also occur between the layers of water at the top and the bottom of the boiler.

In a marine boiler, the difference between the temperatures of the top and the bottom of the boiler is very marked, as there are no under-flues. Hydrokineters and donkey-pumps are requisitioned, when lighting up this type of boiler, both of these appliances requiring steam to operate them; while the Hotchkiss circulator does the work automatically and independently of the supply of steam from another boiler. Such considerable contrasts of temperature occurring in a boiler induce great strains in certain parts, and these exhibit themselves often in a very unaccountable manner.

Although the circulation of the water in the top drums of water-tube boilers cannot assist in increasing the output of steam, as there is practically no fire-surface, yet there are other considerations in tubular boilers, which tend to become of greater importance, such as the deposition of scale, grease in the feed-water, freedom from mud, etc. Whether scale, ¼ inch thick, decreases the efficiency of the heating surfaces by 25 per cent., the writer cannot say, but it is clear that if the thickness of the plate be increased, a greater head of heat must be maintained outside, so as to deliver the same bulk of heat to the water per hour through the greater thickness of plate; and, therefore, it is of great importance that the inside as well as the outside surfaces should be kept clean. The writer may point out that the Hotchkiss automatic circulator, while doing its work as a circulator, collects and removes the suspended solids almost as soon as formed, maintaining a clean surface of the water for the freest possible discharge of steam, preventing priming, and removing

suspended solids, so that the steaming temperature is kept as low as possible.

But the other boiler trouble, oil and grease, is more dangerous and an enemy to be far more feared than scale. Steam can be made with scale, $\frac{1}{2}$ inch thick, on the furnace-flue, but pasty grease, $\frac{1}{16}$ inch and often $\frac{1}{32}$ inch thick, is sufficient to burn any furnace-crown to bursting point.* This danger is greatly minimized, and in most cases completely removed, by the collecting power of the Hotchkiss automatic circulator: it only requires that the oil or the grease should separate and float, then arrange the funnel or funnels to suit the flow, and all danger is removed. Many of the best oils, when the water is very pure, tend to keep in emulsion, even in the boiler: this may require special treatment to induce separation, and then the Hotchkiss automatic separator will remove it. The writer would suggest to those troubled with grease in their boilers that, when a boiler is stopped for cleaning, the surface-water should be blown off from a cock on the boiler-front, say, 6 inches below the water-level, so that the oily skin or scum will be run off and will not shroud the furnace-tube and boiler-shell as it descends.

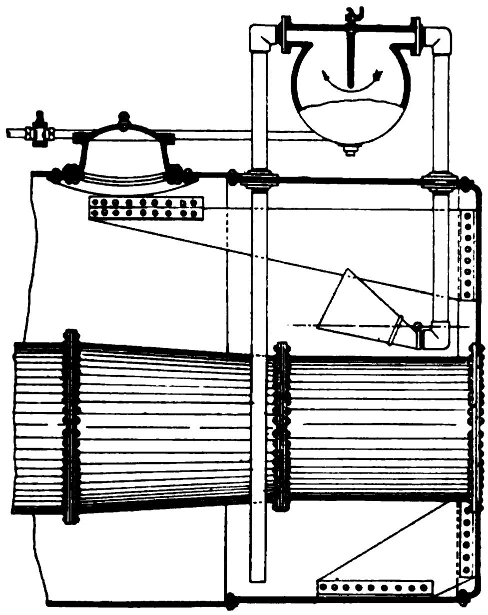

FIG. 8.—CIRCULATOR FIXED ON A LANCASHIRE BOILER.

* "Some Experiments on the Transmission of Heat through Tube-plates," by Mr. A. J. Durston, *Transactions of the Institution of Naval Architects*, 1893, vol. xxxiv., pages 133 and 134.

APPENDIX.—Hotchkiss Automatic Circulator.

Fig. 8 shows a small-sized Hotchkiss automatic circulator fitted on the centre-line of a Lancashire boiler. It consists mainly of a reservoir, a funnel and three pipes.

The funnel is fitted inside the boiler, with the edge just below the lowest working water-level, thus allowing for plenty of fluctuation of level. It is placed as nearly as possible at the back end of the boiler, with the mouth pointing to the furnace-front, and is connected to the reservoir by the pipe passing through the boiler-shell.

The reservoir is a sphere, having three holes at the top, for the inlet-pipe, the outflow-pipe and the air-relief cock; and a blow-off pipe at the bottom. Internally, a diaphragm extends right across, and half way down the reservoir; and this gives the current, from the inlet to the outlet, a longer path and tends to add a downward motion to the deposit. At the bottom of the reservoir, a blow-off pipe is fitted; it is carried to the most convenient place for the stokers' use (generally the stoke-hole), and is provided with a blow-off cock under easy control.

By filling the reservoir and pipes with water before lighting the boiler-fires, circulation commences upwards by the funnel-pipe and downwards by the return-pipe, within a short time of lighting the fires, and never ceases until the boiler is as cold as the surrounding atmosphere.

By this appliance, floating particles of lime, mud, grease or oil, carried upward, by the ebullition, to the water-surface, are caught by the funnel and lifted into the reservoir, where they are deposited in the quieter water and can be blown out from time to time. For the removal of oil in a fluid condition or very light particles of deposit, a second blow-off pipe is fitted in place of the air-relief cock, but in the writer's experience most of the grease is absorbed by the lime-deposits, and removed at the bottom blow-off pipe.

The circulation, having once been set up, rapidly increases in speed, and attains its maximum rate before any steam is formed, taking the hot water from over the furnace-tubes, and discharging it along the bottom of the boiler, where the temperature is lowest. It circulates water only, and steam should never be formed in the connections. The circulation is set up automatically through the difference in temperature between the top and the bottom layers of the water in the boiler; and, having once started, the addition of heat merely increases the speed. Its object is mainly to distribute more equally the heat all over the boiler; and, as the circulation never stops, this diffusion of the heat continues, whether the boiler is lighting up, working, standing under banked fires, or cooling down.

The circulation is its most important function, but, the other operations are also important, such as removing suspended solids, grease and oil, so that the steaming surface is kept clean; and, priming is practically impossible if a proper working level be maintained. The removal of the solids from the water also tends to keep down the boiling-point, so that steam is raised much more easily than would otherwise be the case.

Numerous tests have shewn that economies varying from 3 to 18 per cent. have been made in the coal-consumption, entirely due to the better circulation of the water. Table I. records the results of experiments conducted under the ordinary conditions of working, the same grade of fuel being used in each experiment, and all other things being equal.

TABLE I.—EXPERIMENTS ON FIVE LANCASHIRE BOILERS, 30 FEET LONG AND 8 FEET IN DIAMETER, FITTED WITH MELDRUM FURNACES, AT HAYDOCK COLLIERIES, ST. HELENS.

Experiment.		I. Without Hotchkiss Separator.	II. With Hotchkiss Separator.
Duration of test, ...	hours	310·500	310·000
Water evaporated, ...	pounds	5,222,093·000	5,417,613·000
Coal consumed, ...	„	852,768·000	856,016·000
Ash, ...	„	107,856·000	114,912·000
Average temperature of feed-water,	degs. Fahr.	146·870	132·770
Average boiler-pressure per square inch,	pounds	83·010	85·440
Water evaporated per pound of coal,	„	6·123	6·328
Water evaporated per pound of combustible,	pounds	7·010	7·310
Ash in coal, ...	per cent.	12·640	13·420
Total water evaporated from and at 212° Fahr.,	pounds	5,766,757·290	6,065,017·750
Water evaporated per pound of coal from and at 212° Fahr., ...	pounds	6·762	7·085
Water evaporated per pound of combustible from and at 212° Fahr., ...	pounds	7·741	8·183

The increased evaporation per pound of combustible from and at 212° Fahr. was 5·710 per cent. The average coal-consumption was 22,214,192 pounds per annum, and a saving of 5·710 per cent. is 566·26 tons. In most instances, doubtless, the removal of solids and grease has also tended to increase the economies.

The PRESIDENT (Mr. John Gerrard) moved a vote of thanks to Mr. Ross for his most perfect illustrations of water-circulation in steam-boilers. The question had been clearly demonstrated by means of the practical examples shown by Mr. Ross.

Mr. JOSEPH DICKINSON said that he had much pleasure in seconding the proposition.

The motion was cordially adopted.

Mr. A. ROSS, in acknowledging the vote, said that it had been a pleasure to him to read the paper and to illustrate it with experiments and lantern-views. The priming of boilers was due either to an accumulation of grease or of scum on the surface of the water. The freer the disengagement of the steam from the water, the better the effect, and anything that retarded the discharge of the steam would diminish the efficiency of the boiler.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
MAY 9TH, 1905.

MR. JOHN GERRARD, PRESIDENT, IN THE CHAIR.

The following gentlemen were elected, having been previously nominated:—

MEMBERS—

Mr. ARTHUR ROSS, Colliery Manager, Moston Colliery, Newton Heath, Manchester.

Mr. JOHN SMITH, Colliery Manager, Bower Colliery, Hollinwood, near Oldham.

Mr. FREDERICK SPEAKMAN, Mining Engineer, Church Street, Leigh, Lancashire.

Mr. JAMES E. STEWART, Assistant Manager, Pekin Syndicate's Collieries, North China.

Mr. CHARLES STANLEY WHITWORTH, Assistant Colliery Manager, 24, Montgomery Street, Hollinwood, near Oldham.

ASSOCIATE MEMBER—

Mr. SAMUEL CAMPBELL PRESTON, Close House, St. Helen's, Lancashire.

ASSOCIATE—

Mr. WILLIAM WOODWARD, Assistant Engineer, Lancashire Electric Power Company, 196, Deansgate, Manchester.

Mr. WALTER BALDWIN read the following paper on "*Prestwichia anthrax* and *Belinurus lunatus* from Sparth Bottoms, Rochdale":—

PRESTWICHIA ANTHRAX AND *BELINURUS LUNATUS* FROM SPARTH BOTTOMS, ROCHDALE.

By WALTER BALDWIN.

I. Introduction.—The writer has again pleasure in recording further examples of Arthropoda from the Middle Coal-measure rocks exposed to view at Sparth Bottoms, in the neighbourhood of Rochdale.

The members, who visited this locality last year, will be sufficiently familiar with the ground to recognize that there are at least three horizons on which the remains of fossil Arthropoda occur. The lowest of these has furnished the individuals forming the title of this paper, and has been termed in previous papers* "the *Carbonicola*-bed," on account of the great number of specimens of that genus found in it, which first led to its discovery. The bed lies about 135 feet above the Royley coal-seam.

II. Prestwichia anthrax (Fig. 1).—This is the first recorded example of this species from the Lancashire coal-field and is, on that account, of great interest. Unfortunately, the animal is only represented by the cephalic shield and this is not entire, owing to the absence of the right genal spine, whilst the left is buried in the matrix. This gives the animal a deceptive appearance, as the curious lateral extension, which distinguishes it from all the other king-crabs, is wanting. The frontal doublure is strongly marked. The central portion (the glabella) is prominent and declines towards the circumference: it occupies about two-thirds of the whole depth of the cephalon and is strongly marked by a double arched front as in the Belinuri. The larval

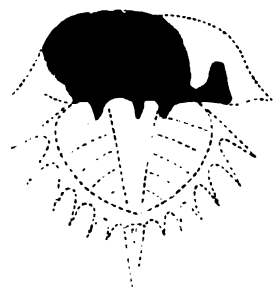

FIG. 1.—*PRESTWICHIA ANTHRAX.* THE RESTORED PORTION IS SHEWN IN DOTTED LINES. FULL SIZE.

* "*Bellinurus bellulus*, from Sparth, Rochdale," by Mr. Walter Baldwin, *Transactions of the Manchester Geological and Mining Society*, 1903, vol. xxviii., page 198; and "*Eoscorpius Sparthensis*, sp. nov., from the Middle Coal-measures of Lancashire," by Messrs. Walter Baldwin and William Henry Sutcliffe, *Quarterly Journal of the Geological Society of London*, 1904, vol. lx., page 394.

eye-spots (two in number) appear on the anterior border of the glabella. The median and lateral ridges of the glabella are continued backward beyond the posterior border of the cephalic shield, forming thereby three prominent spines. These cheek-spines are similar to those on Prof. Joseph Prestwich's specimen,* but are more pronounced and farther apart: they differ from Fig. 6*a* of the same work, as the lateral spines are parallel to the axis.

The following measurements are taken from the Sparth specimen:—Greatest breadth of head-shield preserved, 25 millimetres; greatest length of head-shield preserved, 12 millimetres; greatest breadth of glabella, 9 millimetres; greatest length of glabella, 8 millimetres; greatest length of spines from posterior border of cephalon, 3 millimetres.

This specimen was discovered by Mr. W. A. Parker in 1904, and a further example, but more fragmentary, has been recently found by the writer, on the same horizon.

III. History of Prestwichia anthrax.—*Prestwichia anthrax* was first discovered in the Pennystone ironstone-band of the Coal-measures at Coalbrookdale, Shropshire, and was figured and described in 1834-1836 by the late Sir Joseph Prestwich as *Limulus anthrax* in his important memoir "On the Geology of Coalbrook Dale."† In 1863, Mr. William Hellier Baily classed it among the Belinuri as *Bellinurus anthrax*.‡ Four years later, Dr. Henry Woodward figured and described it as *Prestwichia anthrax* in his paper "On some Points in the Structure of the Xiphosura, having Reference to their Relationship with the Eurypteridæ,"§ and this name is now universally accepted.

IV. Bibliography of Prestwichia anthrax.—

"Remarks on some Coal-measure Crustacea belonging to the Genus *Belinurus*, König; with Description of two new Species from Queen's County, Ireland," by Mr. William Hellier Baily, *Annals and Magazine of Natural History*, third series, 1863, vol. xi., page 107.

"On the Geology of Coalbrook Dale," by Mr. Joseph Prestwich, Jun., *Transactions of the Geological Society of London*, second series, 1840, vol. v., page 413.

* *A Monograph of the British Fossil Crustacea, belonging to the Order Merostomata*, by Dr. Henry Woodward, Part V., page 244 and Plate XXXI., Fig. 6, Palæontographical Society, 1878, vol. xxxii.

† *Transactions of the Geological Society of London*, second series, 1840, vol. v., page 491.

‡ *Annals and Magazine of Natural History*, third series, 1863, vol. xi., page 113.

§ *Quarterly Journal of the Geological Society of London*, 1867, vol. xxiii., page 32.

"On some Points in the Structure of the Xiphosura, having Reference to their Relationship with the Eurypteridæ," by Dr. Henry Woodward, *Quarterly Journal of the Geological Society of London*, 1867, vol. xxiii., page 28.

A Monograph of the British Fossil Crustacea, belonging to the Order Merostomata, by Dr. Henry Woodward, Part V., Palæontographical Society, 1878, vol. xxxii.

V. Belinurus lunatus (*olim B. bellulus*).—For this species, the writer has, after some consideration, adopted the term *lunatus* as being the most descriptive. A short time ago, Dr. F. A. Bather suggested this name to the writer, his reason being that it had been termed *Monoculus lunatus* by Mr. William Martin in 1809,* whereas Mr. Charles König figured it as *Belinurus bellulus* in 1825.† It is certainly not a *Monoculus*, and as Mr. William Martin's names are universally accepted, *Belinurus lunatus* appears to be the most correct.

Previous to the discovery of the present specimen (Fig. 2), the writer had described a head-shield of *Belinurus* from the same horizon at Sparth.

The present one, however, possesses points which are worthy of description. The head-shield is somewhat crushed, and demands no special attention. The thoracic segments, five in number, are strongly trilobed, and possess a narrow central axis with the median portion of each somite marked by a single tubercle. The lateral extremity of each segment is produced, so as to form an acutely pointed and recurved spine: they are lanceolate in form, and differ somewhat from the examples figured in Dr. Henry Woodward's *Monograph of the British Fossil Crustacea belonging to the Order Merostomata*, having much broader bases.‡ The thoracic segments are considered by Dr. Woodward to have been capable of flexure, thus forming a distinctive feature as compared with *Prestwichia* in which they are anchylosed. The abdomen is trilobed and also

FIG. 2.—*BELINURUS LUNATUS.* THE RESTORED PORTION IS SHEWN IN DOTTED LINES. FULL SIZE.

* *Petrificata Derbiensia; or, Figures and Descriptions of Petrifactions collected in Derbyshire*, by Mr. William Martin, 1809, Plate 45, Fig. 4.

† *Icones fossiles sectiles*, by Mr. C. König, 1825, Plate XVIII., Fig. 230.

‡ Part V., page 239 and Plate XXXI., Figs. 3*a* and 3*b*, Palæontographical Society, 1878, vol. xxxii.

possesses a central axis, which is not divided into somites, and bears a large tubercle anterior to the point of insertion of the telson. The lateral somites of the abdominal segments are marked by sutures, and terminate laterally in spines similar to those of the thoracic segments. The telson has a well-marked central ridge, and (though not entire) appears to have been not quite so long as the rest of the animal.

The following measurements are taken from the fossil:—Total estimated length, 37 millimetres; greatest length of head-shield preserved, 8 millimetres; greatest breadth of head-shield preserved, 21 millimetres; greatest length of glabella, 8 millimetres; greatest length of thorax, 7 millimetres; greatest breadth of thorax, exclusive of spines, 16 millimetres; greatest length of abdomen, 2·5 millimetres; greatest breadth of abdomen, exclusive of spines, 9 millimetres; greatest length of thoracic spines, 2 millimetres; greatest length of telson preserved, 9 millimetres; and greatest width of telson, 2 millimetres.

This *Belinurus* was discovered by Mr. W. H. Sutcliffe, and with the *Prestwichia anthrax* is in the collection of Messrs. W. H. Sutcliffe, W. A. Parker and the writer.

VI. Bibliography of Belinurus bellulus.—

"*Bellinurus bellulus*, from Sparth, Rochdale," by Mr. Walter Baldwin, *Transactions of the Manchester Geological and Mining Society*, 1903, vol. xxviii., page 198.

"The Palæontology of the Lancashire Coal-measures," Part II., by Mr. H. Bolton, *Transactions of the Manchester Geological and Mining Society*, 1904, vol. xxviii., page 578.

"Notes on some Fossil Crustacea, and a Chilognathous Myriapod, from the Coal-measures of the West of Scotland," by Dr. Henry Woodward, *Transactions of the Geological Society of Glasgow*, 1866, vol. ii., page 234.

Prof. W. Boyd Dawkins said that he had great pleasure in moving a vote of thanks to Mr. Baldwin for his paper. By his work at Sparth Bottoms, Mr. Baldwin was doing admirable service in the general interest of geology and of this society, and he was one of an ardent band of explorers, which included Mr. Sutcliffe and Mr. Parker.

Mr. W. Saint seconded the motion, which was cordially adopted.

The PRESIDENT (Mr. John Gerrard) asked whether nodules containing similar specimens had been found over the Arley mine in other parts of Lancashire.

Mr. W. BALDWIN replied that this was the only horizon in the district at which he had worked and found them, but he believed that *Belinurus lunatus* had also been found in the Oldham district.

The PRESIDENT (Mr. John Gerrard) remarked that the fact of Sparth Bottoms being an open quarry facilitated research.

Prof. W. BOYD DAWKINS said that there was a layer above the Five-Quarters mine exposed in the section near Clifton, on the banks of the river Irwell, where there was a large number of nodules containing similar remains. He had also obtained some from other localities.

Mr. W. BALDWIN said that some very important specimens were still being found in the same locality.

DISCUSSION ON THE CAPPING OF WIRE-ROPES.*

The PRESIDENT (Mr. John Gerrard) said that his attention was called to this question by several breakages of ropes within caps in actual winding. In a number of cases, the break occurred at the base of the cap, where the wires were turned back to form the bulge to be gripped by the cap. These caps were of three forms: (1) The common one, where the rope was opened and the wires turned back on the rope, enclosed within a cap held by several hoops; (2) one in which the wires of the rope were turned back over tongues or cones of metal, the cap again being held by several hoops; and (3) another form, in which the turned-back wires were combined into a solid cap or socket of white metal. All of these had failed in actual use. When caps were made on similar lines, and submitted to measured tests, at the Sheffield, Birkenhead or Dudley testing-works, it was proved that these caps only gave from 40 to 60 per cent. of the breaking-strain of the ropes. To his mind, this was far from satisfactory. Mr. W. C. Blackett,† in 1901, submitted a cap in

* *Trans. Inst. M. E.*, 1905, vol. xxix., page 604.

† "A Method of Socketing a Winding-rope, etc.," *Ibid.*, 1901, vol. xxiii., page 10.

which the wires were not turned back: they were spread out straight within a solid socket or cap, and white metal was run so as to form a solid cone; and with this cap Mr. Blackett obtained, under tests, 80 per cent. of the breaking-strain of the rope. In Lancashire, at Ladyshore colliery, Mr. Herbert Fletcher introduced a somewhat similar cap 28 years ago, and this had continued in use up to the present time at three shafts. It had now been proved that by giving attention to the composition of the white metal, using lead, 60 per cent.; tin, 30 per cent.; antimony, 9 per cent.; and bismuth, 1 per cent.; also by well cleaning the wires with paraffin, and by using resin-dust amongst the wires before running in the white metal, a capping could be made stronger than the rope.

Mr. F. L. Ward said that, in consequence of a winding-rope breaking at Bradford colliery, it was considered advisable to investigate the question of the efficiency of the system of capping. The rope broke inside the capel at the turned-back wires or bow, although it had only been at work a little over half the usual time of similar ropes, and subsequent tests of the broken wires revealed no undue weakness or deterioration.

The system of capping that had been in use for over 20 years without previously giving any cause for doubt was the usual type of hooped capel, having a total length of about 36 inches. The rope was wrapped tightly with soft iron-wire for the whole length of the capel, leaving the ends of the rope-wires projecting for turning back. Several extra layers of soft iron-wire were put on at the end, to form a cushion for the turning back of the wires which varied from 4 to 14 inches in length, so as to form a cone, when put on the soft iron-wire preparation. The whole was then tightly wrapped with soft iron-wire, and the capel (heated at the bottom of the eye) closed on to this cone. Three hoops, previously threaded on to the rope, were brought on to the capel and driven down until quite tight.

It was decided to have some capped ropes tested, and although confidence in the system of capping was not materially lessened by the breakage mentioned, the results of the tests were startling. (1) The first sample, being a piece taken from the winding-drum end of a disused improved patent steel rope, 3¾ inches in circumference, was capped in the usual manner. On the testing-

machine, it commenced to draw out of the capel with only 12 tons of load, and continued to move until a load of 28·35 tons was reached, when it broke and came completely out. On investigation, it was found that the rope had broken at the inside of the turned-back wires, or in exactly the same way as the breakage already referred to. (2) The second sample was a capel, 24 inches in length over all, with three hoops, and the same preparation as the first sample, excepting that, being shorter, the length of the cone was reduced and consequently sharper. This test gave better results, and stood a load of 32·2 tons before breaking and drawing out. The breakage was exactly in the same place as in the first sample, that is, at the turn-back of the wires. (3) The same capel was again prepared, but, instead of wrapping it with soft iron-wire, tarred string was used. The load reached on testing was 26·68 tons, when the turned-back wires drew out without breaking.

Attention was then given to the question of socketing the end of the rope by running in white metal to form a cone. It was observed at the testing-works of the Sheffield Testing-works, Limited, who carried out all the tests, that, in order to ensure a firm hold by the testing-machine of the opposite end of the rope to the capping a metal-cone was formed, and this was stated to have been the practice for a great many years. Forged-steel sockets were procured, bored to form a cone, 8 inches long with a taper of 1 inch, that is, 1 inch larger in diameter at the bottom-end than at the top-end. For attaching to the cage, two ears, bored to receive a steel pin or bolt, project below the cone. (1) In the first test of a metal-cone, the socket was threaded on, and the rope wrapped for about 2 inches with soft iron-wire immediately above the position of the socket. The wires were opened out, without interfering with the twist of the rope, and the ends turned back (inwards) about ¾ inch. The socket was then drawn down to cover the end of the rope, and without any preparation of the wires by cleaning, white metal composed of magnolia-metal, with a little lead added to soften it, was poured in. On testing, the rope broke outside the socket under a load of 43·8 tons. The movement of the cone inside the socket during the test was very small, and only reached 0·20 inch at 40 tons. (2) For the second test, the preparation was similar to the last, excepting that the ends of the wires were straight, and not turned back. The result

was that some of the wires drew out of the metal under a strain of 32·35 tons, indicating that the turned ends of the wire have an effect in resisting the strain. It was noticed that the wires drawn out had not separately been in contact with the white metal, but that there were several lying together.

Three further tests were subsequently made, the wires being straightened and the twist taken out, one having the ends turned back and the other two with straight projecting ends. After opening out the wires, they were washed in petroleum to remove all grease, and afterwards wiped and held over a red-coke fire. Powdered resin was then sprinkled on, and after the socket was placed in position, a further quantity was blown in amongst the wires by means of a small tube. The mixture of metal used was 70 per cent. of magnolia-metal and 30 per cent. of pure tin. The magnolia-metal was melted and the tin put into it, and immediately this was molten the mixture was poured into the sockets, so that any possibility of pouring on to the rope a metal of very high temperature was avoided. On testing, all the ropes broke some distance from the sockets at a load of 42½ tons. As two of the three test-pieces had not the ends of the wires turned back, proof was given that the metal adhered to the wires. The movement of the cones in the sockets during the tests varied from 0·02 inch to 0·11 inch at a strain of 35 tons.

A test was also made of a locked-coil rope, 1 inch in diameter, the rope breaking outside the socket with a load of 37·97 tons and a movement of 0·40 inch at a strain of 35 tons.

In practice, the socket is warmed before the metal is poured in, to such an extent that the hand cannot be held on it. After the socketing is completed it is allowed to cool before any load is applied.

Metal-filled sockets are now in use at the colliery, and, so far, have not given any cause for doubting their efficiency.

Referring to the temperature of the white metal and the possibility of altering the temper of the steel-wires of the rope by pouring into the socket, Mr. N. K. Turnbull, general manager for Messrs. Richard Johnson & Nephew, Limited, wire-drawers, stated that up to 900° Fahr., steel-wire will not be affected, if not hammered or in any way worked. This temperature is about the average one used in galvanizing steel-wires, without materially altering their tensile strength.

Mr. J. WHITTAKER said that he had used locked-coil winding-ropes for about 16 years. A solid cone cap was used and formerly the wires were bent back to form a sort of cone, which was drawn into the cap, and the cavity filled up with a mixture of equal parts of lead and tin. In recapping, a few of the wires were sometimes found broken at the bend. One winding-rope had entirely broken in the cap. It was of improved plough steel, 4 inches in circumference, having a breaking strength of about 90 tons and a load of 7½ tons. The rope had only been at work for about 7 months. The wires were bent back as usual in capping and filled up with lead and tin. All the wires broke at the bend and the rope drew out of the cap, leaving the broken wires embedded in the white metal. Probably, the steel was too hard to bear the bending without injury. The wires were now only opened out like a brush and not bent back, and the cavity was filled with lead and tin as before. Various tests shewed that when the wires were bent back in the cap, they broke at about 55 per cent. of the ultimate strength of the rope, and when they were opened out only and not bent back they broke at about 80 per cent. of the ultimate strength.

Mr. JOSEPH DICKINSON stated that, in most of the cappings exhibited, the rope was verging on a very sharp edge. Now, in the ordinary winding of collieries, the rope and the cap seldom keep perfectly straight at the bottom: they are there a little slack. It would be better to take the edge off, thus forming a little bell-mouth.

Mr. F. L. WARD said that the rope at the Bradford collieries was covered with white metal to the limit of the capping, which ended with a small bell-mouth.

The PRESIDENT (Mr. John Gerrard) said that one of the advantages of having the cap made of molten metal was the exclusion of water and, with it, the risk of corrosion. In the old form, rust was found, but it could not possibly accumulate in the new form of cap. He (Mr. Gerrard) objected to Mr. Whittaker's form of cap, because it embodied the old principle of capping, that was, by turning back the wires of the rope, and bending was the first step to breaking anything. In this way, the pernicious, unscientific and absolutely objectionable form of capping by bending back the wires was continued.

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Mr. Peter Thompson said that at the Chamber collieries, after some disappointment he ... which he was connected, ... required to put ferrules on the end of the ropes and weld them together, as shown in the model exhibited. The result had been quite successful, and there was no danger of slipping.

Mr. William Saint said that, when visiting the United States of America in the early eighties, he noticed that colliery winding-ropes were capped with conical capels, which were secured by means of white-metal filling. This method was considered to be safer in use, and more expeditious to make, than the ordinary form of capping used in this country. The only case of failure of a solid capped rope of which he knew was one in which the rope had been bound at the neck of the cap with copper-wire; and the fracture occurred at the neck of the cap. At first it was supposed that the temper of the wires had been affected by the molten metal when the capping was made; but, on separating and testing the embedded wires, they were found to be as good as when they were new. It was supposed that in some way galvanic action had been set up between the copper- and steel-wires where they were bound together, and had thus diminished the strength of the rope.

The further discussion was adjourned.

Prof. W. Boyd Dawkins read a "Note on the Discovery of the South-eastern Coal-field."

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

GENERAL MEETING,
HELD IN THE ROOMS OF THE SOCIETY, QUEEN'S CHAMBERS,
5, JOHN DALTON STREET, MANCHESTER,
JUNE 20TH, 1905.

MR. JOHN GERRARD, PRESIDENT, IN THE CHAIR.

The following gentleman was elected, having been previously nominated:—

ASSOCIATE MEMBER—
Mr. ARTHUR ROSS, 1 Glengall Road, Old Kent Road, London, E.C.

The PRESIDENT (Mr. John Gerrard) said that it was with great regret that he had to announce the deaths of Mr. George Peace and Mr. Thomas Banks. Both were Lancashire mining engineers of high repute, and both had long been connected with this Society. He begged to propose a silent vote of sympathy with the relatives of both gentlemen.

The vote was passed in silence, the members rising.

DISCUSSION ON THE CAPPING OF WIRE-ROPES.*

Mr. JOSEPH DICKINSON stated that none of the cappings produced showed a bell-mouth to prevent any cutting action, where the rope emerged from the cap; and he would be glad to hear some reference to this point, which he had mentioned when the subject was introduced at the previous meeting.

The PRESIDENT (Mr. John Gerrard) said that a new cap had been described, at a recent meeting of the South Wales Institute of Engineers, by Mr. W. H. Becker.† Mr. Becker had sent a

* *Trans. Inst. M. E.*, 1905, vol. xxix., pages 604 and 625.

† *Proceedings of the South Wales Institute of Engineers*, 1905, vol. xxiv., page 151.

model of the capping, together with several pieces of rope which had been tested. This cap consisted of sliding interlocking wedges, of special construction, held together by a number of encircling hoops. The records of the tests were attached to each rope, showing the strain under which each broke, namely, 65 tons, 45 tons, 65 tons, 64½ tons, 42½ tons and 67½ tons. The notable points were that the inventor claimed to get 100 per cent. of efficiency in the caps, and that, in every case, the rope broke outside the cap.

Mr. WILLIAM PICKUP said that the point mentioned by Mr. Dickinson was an important one. His first experience of the use of solid caps was for haulage-purposes, and then he found that the wires of the rope were apt to break, just where they emerged from the cap. If the edge of the cap was slightly hollowed, as Mr. Dickinson recommended, it would, he thought, be an improvement, and might prevent the wires from breaking at that point.

His experience of winding-rope caps and their improvement began some years ago. At that time, at the colliery with which he was connected, a cap was used with rivets through it, between the collars. He did not like the rivets, feeling sure that they had a bad effect upon the rope, and he, therefore, arranged that the caps, as they were taken off, should be taken to pieces and examined. He found that a number of wires were broken, in all cases, where the rivets had gone through the rope; and that these rivets, instead of being a source of strength, were distinctly a source of weakness. The cap, with rivets through the rope, was then discarded, and he adopted the type now generally used, in which iron cones were applied in halves and the wires of the ropes turned back over them: the cap, being then closed on and held in position by collars, well driven down. This latter type was used until quite recently, when he increased the margin of safety of the winding-ropes from 8 to 10 times the working-load. In connection with this, it seemed rather absurd to be increasing the strength of the winding-rope to 10 times the working-load, when the strength of the cap was not known; and, accordingly, a series of tests were made to ascertain the strength of the cap. He was surprised to find that in the first case only 58 per cent., and in the second case only 65 per cent.,

of the breaking-strain of the rope was obtained. This was considerably less than it ought to be, although the caps were made in the usual way by a thoroughly good blacksmith, under the supervision of a capable enginewright. He then had a number of caps made for testing purposes, increasing in solidity each time, until this form of cap was eventually able to withstand 90 to 95 per cent. of the breaking-strain of the rope.

Whilst engaged in these tests, he reverted to the solid cap, and thought that it would be still better if the full strength of the rope could be obtained. He accordingly had further tests made, and found that it was only a question of the composition of the white metal; certain alloys proved too soft, but various others were found to give the full breaking-strain of the rope. Mr. Gerrard had communicated to him the composition of an alloy, which gave the full strain of the rope; and it had the further advantage of a comparatively low melting-point. Some engineers might be nervous about adopting the solid cap, the strength not being so obvious and mechanically apparent as the form that they were accustomed to use; but it was only a matter of gaining experience and of becoming accustomed to it—especially by seeing one or two caps tested to destruction, and observing how they behaved.

With respect to the cap invented by Mr. Becker, it appeared to be designed on the lines of the grips, used in certain proving-houses, for quickly getting hold of ropes brought for testing. There, the strength of the grips depended upon the pressure applied to the circumference of the rope. This form of cap did not get hold of the internal wires, except by the pressure applied to the circumference of the rope by the circular wedges as they tightened. He (Mr. Pickup) feared that, with a locked-coil rope, the inner rings would be liable to be withdrawn.

Mr. H. H. Bolton said that he would like to corroborate what Mr. Pickup had said about a capping of the form introduced by Mr. Becker not being adapted for use with locked-coil ropes. The grips used for testing ropes at Dudley were similar to it, the outer wires were broken during the test, leaving the inner wires intact, and the rope became so much weaker. The cap might be feasible for use with ordinary ropes, but he certainly did not think that it would be useful in the case of locked-coil ropes.

The PRESIDENT (Mr. Gerrard) remarked that he had seen a Becker cap tested, and the rope broke just within the first hoop, where the nip was, at about 98 per cent. of the efficiency of the rope. In other words, it broke at rather less than the full breaking-strain.

Mr. WILLIAM PICKUP said that, although he had not known a cap of the usual construction to fail in actual work, and had not heard of one failing, it did not dispose of the fact that, although most engineers were satisfied with these caps, they were surprised to find their weakness on going into the question. When one or two caps had been tested, and found to give only 50 or 60 per cent. of the breaking-strength of the rope, he thought that there was ample room for improvement. And if, at the same time, another type of cap could be got, which would give the full breaking-strain of the rope, it ought to be considered as being much more suitable for use. He thought that confidence in the strength of the solid cap would come from experience in use.

The PRESIDENT (Mr. John Gerrard), in closing the discussion, thanked the members who had taken part therein, and the many friends who had so kindly supplied him with the results of tests and much valuable information. Mr. W. Pickup stated that "he had not known a cap of the usual construction to fail in actual work, and had not heard of one failing." It was by reason of several failures in actual work that his (Mr. Gerrard's) attention was directed to this question: when he read the admirable paper by Mr. W. C. Blackett on his method of socketing a winding-rope,* it appeared to him that the method deserved serious consideration; and he had found that Mr. Blackett's strictures and condemnation of the ordinary methods of capping ropes were fully justified. He might be permitted briefly to allude to several points, which appeared to him to be prominent in connection with this subject. It appeared to be conceded that the form of capping which depended upon rivets was liable to damage the ropes; that the capping which depended upon a bulge, formed by turning back the wires of the rope, the cap being gripped by a number of hoops, had been proved by a

* "A Method of Socketing a Winding-rope," by Mr. W. C. Blackett, *Trans. Inst. M. E.*, 1901, vol. xxiii., page 10.

number of tests to be unreliable: only 50 to 60 per cent. of the strength of the rope being ordinarily obtained by this method; and that the solid-metal cap had been proved by repeated tests to give a strength greater than that of the rope. Various views had been expressed as to the practicability of this method; it had been stated that ordinary colliery-blacksmiths could not be trusted to make this cap. His answer to that was, that, where this method was in operation, the ordinary colliery-blacksmith had proved that he could be trusted to do the work. In conversation, these men had expressed their view that they preferred this method to the old one; the results were more reliable than when they had to depend upon the care called for in bending back the wires, in wrapping them, and in driving the tightening encircling hoops home. It had been stated that the heat of the molten metal would affect the temper of the wires of the rope; but experience had proved that there was no foundation for this fear. They had moved very slowly in these matters; but it was very gratifying to him to find that a number of mining engineers were resolved to prove for themselves whether the old method of capping ropes could be depended upon, and were sending caps to be tested. A year ago, he drew the attention of the President of the Midland Institute of Mining, Civil and Mechanical Engineers to this subject, whereupon Mr. T. W. H. Mitchell wrote two papers, and initiated several very interesting discussions.†

Mr. Gerald H. J. Hooghwinkel read the following paper on "Electric Pumping at Collieries":—

† (1) "Notes on Capels for Winding-ropes," by Mr. T. W. H. Mitchell, *Trans. Inst. M. E.*, 1905, vol. xxix., page 173. (2) "Further Notes on Capels for Winding-ropes," by Mr. T. W. H. Mitchell, *Ibid.*, 1905, vol. xxx., page 239.

ELECTRIC PUMPING AT COLLIERIES.

By GERALD H. J. HOOGHWINKEL, M.Inst.Elect.E.

One of the first applications of electric power to the driving of mining plant was the electrically-driven mining pump. The disadvantages of steam as a direct motive-power are obvious, if one only considers underground pumps and shaft-sinking pumps, with long and leaky steam-ranges, obstructing the shaft to such an extent that shaft or pipe-repairs become exceedingly difficult, without stopping the pumps. These disadvantages, together with the high cost of the steam-installation and the heavy repairs, have given the first impulse for the use of electricity in the underground workings of collieries.

The writer proposes, for the present, to deal with underground pumps only, because they are quickly superseding surface-engines and show the many advantages of electric driving, to a greater extent, although the benefit to be derived by using electricity for surface-work is in no way diminished.

It will not be necessary to repeat the disadvantages of placing steam-driven pumps underground, where the use of steam and the increase of temperature always constitute a danger. In the deep workings of the future, the use of steam-driven pumps for underground work is an impossibility.

Pumps.—The only types of pumps available, until recently, were slow-speed ram, piston- or bucket-pumps, according to the lift required; but on account of the shorter strokes and smaller masses to be moved, underground direct-driven steam-pumps were worked at higher speeds than surface-pumps. However, even these comparatively low speeds were not very suitable for coupling to electric motors without the use of gearing. As gearing was thought to be objectionable by most mining engineers, a prejudice which is not shared by the writer, the electrical engineer was asked to reduce the speed of his motor to such a point that two of the great advantages of electric

motors, namely, cheapness and small dimensions, almost disappeared. The writer has installed many geared pumps of large dimensions, and they are running satisfactorily and without noise. For small pumps, belt-driving with high-speed motors, which show a high efficiency at various loads, may be used, at least in pump-rooms where the atmosphere is not too much saturated with moisture.

The desire to use moderately high-speed motors resulted in the design of high-speed pumps, such as the Riedler, the Bergman, and several others, using mechanically-aided valves, operated by levers, cams or excentrics. These high-speed pumps were to be used for high lifts; but lately the speed has been reduced, so as to ensure absolute security from breakdowns owing to valve-troubles, etc. For pumping-plant, especially at mines, safety from breakdown is the one and only condition which must be satisfied before everything else, even before high efficiency; and, as will be seen later on, the electric motor has been instrumental in bringing into favour a class of pumping machinery which fulfils this condition, and so far had been very rarely used for underground pumping. The first Express pump of large capacity was run at 200 to 300 revolutions per minute, but this speed has been gradually reduced to 120 to 180 revolutions, which is an immense advance on the old-fashioned slow-speed pumps at 50 to 80 revolutions, and still allows of the use of electric motors of fairly economical design and low first cost.

For small pumps, the speed may be somewhat higher, and for such pumps belt-driving is advisable, if there is enough space in the pump-room: the loss in the belt being equalized by the higher efficiency of the motor.

The latest electrically-driven mining pump (in the opinion of the writer, destined to supersede all other pumps and first of all the steam-driven pump) is the electrically-driven high-pressure centrifugal pump. The centrifugal pump is, of course, an ideal mining pump, on account of its many and valuable qualities, namely:—(1) Cheapness, about one-sixth; (2) small dimensions and compactness; (3) strong construction and almost absolute security from breakdown; (4) possibility of pumping dirty and gritty water; and (5) small pump-room required. The commercial construction of high-pressure centrifugal pumps is of

recent date, and is due almost entirely to Messrs. Sulzer Brothers of Winterthur. Now, any lift can be attained up to 750 feet with one pump only; and for higher lifts, with two or more pumps in series.

The first large installation erected on this principle was the pumping-plant for the Hocayo mines, Spain. Small centrifugal pumps, driven by electric motors, were installed on each pumping-level as the workings increased in depth. The pumps needed no supervision, and the loss of energy, usually incurred by letting the water flow and accumulate in the sump at the pit-bottom, was avoided. Another advantage was that the capacity of the installation could be gradually increased, with very little cost. With plunger-pumps, either steam or electrically driven, a

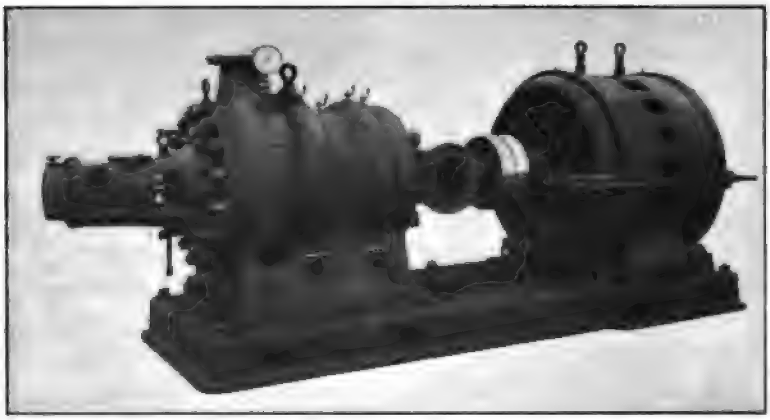

Fig. 1.—Underground Electric Pumping Plant at the Ems Lead-mine: the Sulzer Centrifugal Pump will raise 550 Gallons of Water per Minute to a Height of 837 Feet, and the Motor of 225 Horsepower runs at 1,465 Revolutions per Minute.

division of the pumping-plant in this manner would be impossible, owing to the high cost and still higher working costs. The water pumped from its proper inflow-level is also much clearer, and has therefore a certain value when brought to the surface.

Modern high-pressure centrifugal pumps may be divided into two distinct classes, namely, the Sulzer pump and the Rateau pump. Various firms on the Continent and in the United States manufacture either of these types on licence, or a pump of their own, which may be more or less a combination of both principles.

The Sulzer pump consists of one or more rotating impellers, containing spirally-curved guide-blades and fixed guide-wheels, provided with spirally-curved water-passages. The water is thrown radially against the fixed guide-wheels and through openings in the latter, back again against the blades of the next propeller, which throws it through openings in the periphery of the fixed guide-wheel in the pressure-chamber surrounding the guide-wheels. Thence, the water flows through channels to the next impeller-system or to the discharge, if it is a single-stage pump. Gradually the velocity is transformed into pressure by means of expanding channels. This pressure varies of course with the speed of the impellers, but it may be taken as about 225 feet of head per impeller-stage. With four impellers, therefore, a head of 800 feet may be taken as normal (Fig. 1). For higher lifts,

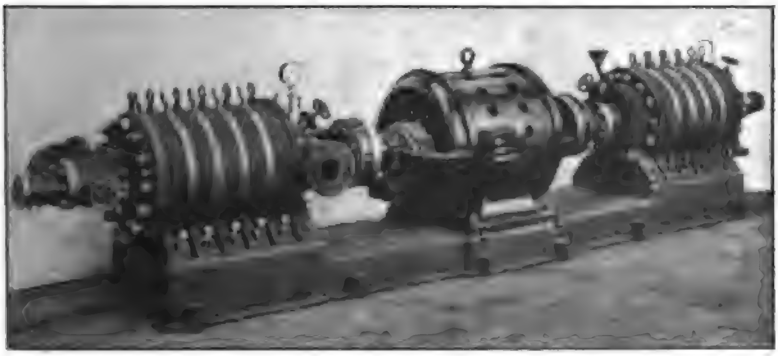

FIG. 2.—UNDERGROUND ELECTRIC PUMPING PLANT AT THE BLIESENBACH COLLIERY: THE TWO SCHWARZKOPF CENTRIFUGAL PUMPS IN SERIES WILL RAISE 220 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 1,083 FEET, AND THE MOTOR OF 106 HORSEPOWER RUNS AT 1,450 REVOLUTIONS PER MINUTE.

two pumps in series, coupled to one motor in the centre, may be used with advantage (Fig. 2). The impellers and the guide-wheels are made of bronze. The axle, of nickel-steel, is supported on two self-oiling bearings. Another great advantage is the ease with which the wheels can be changed, and even with the largest sizes, it does not take longer than 2 hours. Only spare impellers and guide-wheels need, therefore, be kept in reserve, instead of a complete pumping set, as with plunger-pumps. The pumps are coupled to the motors by means of elastic couplings. The suction-pipe is provided with a safety-valve and foot-valve. The former prevents the water in the rising-main from entering the pumps and pressing against the foot-valve.

The first important installation of centrifugal pumps of high capacity against a head of over 1,800 feet placed at the pit-bottom was carried out at the Victor-Rauxel colliery, Westphalia (Fig. 3). Two pumps are installed in series, each having a capacity of 1,500 gallons of water per minute against a head of 900 feet. This plant has now been running for two years, night and day, without a single hitch. An official test showed the following results:—Steam-engine, 90 per cent.; generator, 94 per cent.; cables, 99 per cent.; motor, 93 per cent.; and pumps 75 per cent.; the total efficiency being 59 per cent.

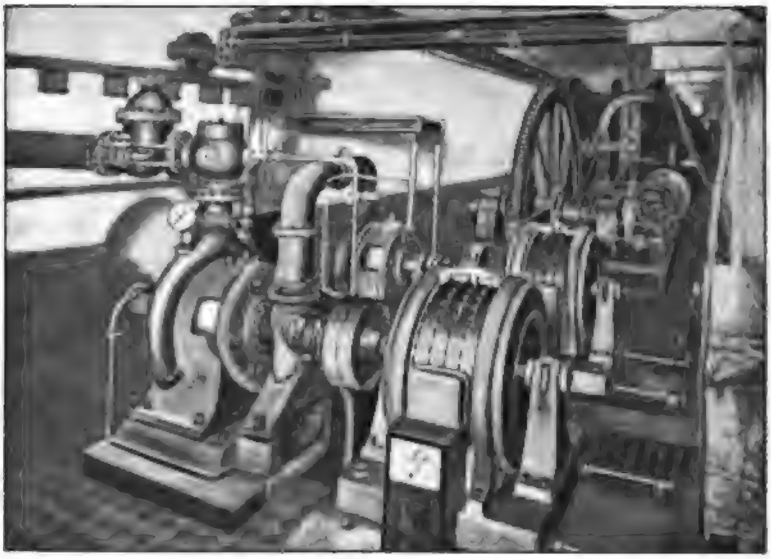

FIG. 3.—UNDERGROUND ELECTRIC PUMPING PLANT AT THE VICTOR-RAUXEL COLLIERY: THE TWO SULZER CENTRIFUGAL PUMPS IN SERIES WILL EACH RAISE 1,500 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 900 FEET, AND THE TWO MOTORS EACH OF 600 HORSEPOWER, AT 5,000 VOLTS, RUN AT 960 REVOLUTIONS PER MINUTE.

The Rateau pump is built on another principle, as the water does not leave the impellers in a radial direction, but in an axial one. In the Sulzer pump, the water flows on the impellers in an axial direction and is thrown out radially; but, in the Rateau pump, the water enters the passages of each impeller at the centre and, by the rotation, is forced out to a collecting-chamber surrounding the periphery of the impeller. The ducts which return the water back to the centre of the impeller are suitably curved

to act as guide-passages, similar in action to the guide-buckets of a turbine. The water then enters the impeller in an axial direction, its rotary motion having been transformed by the guide-passages into rectilinear motion. Many pumps have been built on the Rateau principle, in Germany as well as in the United States; and a combination of the Sulzer and Rateau pumps forms the Schwarzkopf pump. Centrifugal pumps are mostly provided with a special balancing arrangement (that of the Sulzer being kept secret), usually consisting of a hollow plug, at the bottom-chamber, adjusted by screws, causing the impeller-system to balance by the reaction of the water. This compensates the resulting end-thrust in horizontal pumps, and in a vertical (sinking) pump the excess pressure of the water.

The efficiency of the Rateau pump is slightly higher than that of the Sulzer pump, and may be taken as between 65 and 80 per cent. It can be used for pumping smaller quantities of water at greater heads, while the Sulzer pump is more adapted for large quantities and lower heads. So far as their appearance and construction are concerned, the Sulzer pump has few wheels of large diameter, while the Rateau pump has many wheels of small diameter: in fact, it closely resembles the Parsons turbine. The number of wheels on a Rateau pump, for a head of 600 feet, varies from 8 to 10, necessitating a long pump-body and a high speed. In fact, the increase of pressure per wheel in a Rateau pump is about 1·5 to 2 atmospheres, while in a Sulzer pump it reaches 25 atmospheres.

A recently installed Rateau pump in the Carmaux colliery, France, has a capacity of 80 gallons per minute to a vertical head of 1,350 feet, at a speed of 2,900 revolutions per minute.

Electric Motors.—The electrical part should consist of a high-speed three-phase motor, because it is the cheapest and best-adapted electric motor for mining purposes, and may be worked up to an output of 100 horsepower without a starting switch. Instead of the latter, it is equipped with a centrifugal compensator, which can be made completely gas-and-water tight, and it cuts out the starting resistances automatically. The point is to construct a motor running at a medium speed, and well ventilated so as to show no high temperature-rise after a 24 hours' run. Another required condition is the possibility of

regulating the position of the stator part of the motor, as the small clearance between the rotor and the stator with three-phase motors (continuous-current motors are not very suitable for underground pumping) soon necessitates a readjustment of the clearance, after continuous running, perhaps for months, without stopping. For large motors, it is essential that they be constructed in many parts, so as to permit of easy transport in the shaft and narrow roadways. Motors of a capacity of 200 horsepower and more should be provided with slip-rings, and these can be completely enclosed, so as to be water-and-gas tight. They must be so well ventilated that, after continuous running for any considerable length of time, their temperature-limit is not reached.

A three-phase motor of modern construction may be considered free from breakdown, and it is therefore not necessary to provide spare units. It is good practice to mount the motor between two pumps, one being a spare, or between the two cylinders of a two-cylinder pump. Direct driving, although not absolutely necessary, is to be preferred, especially for large sets. If gearing is used, bronze wheels and raw-hide pinions should be employed in order to avoid noise, which is most objectionable in a mine, and constitutes a real danger. The motor may also be mounted side by side with a three-cylinder pump, but this arrangement has the disadvantage that all parts of the pump are not so easily reached as with the motor placed in the centre. In the former case, however, the motor should be provided with a revolving mass, either in the rotor or in the shape of a separate fly-wheel, so as to ensure an even turning moment.

Of course, where existing slow-speed steam-pumps have to be converted into electrically-driven pumps, special motors must be built, and this sometimes necessitates very special designs. In a case within the writer's experience, a steam-driven pump, making 68 revolutions per minute, had to be converted by replacing the steam-cylinder by a 150 horsepower three-phase motor, working at a periodicity of 21 and therefore requiring 38 poles. This again required a large stator, which had to be especially stiffened by means of end-shells, so as to ensure safety from breakdown with a clearance of only 0·07 inch.

Specially stiffened frames, however, are very expensive, and a very small clearance is in every way undesirable from a

running point of view. This may be avoided by using a motor with a double armature, having about half the diameter of an ordinary slow-speed motor, but more than double the length, which is no disadvantage. Two rotors and two stators are placed next to each other and combined into one. Each stator and each rotor has, therefore, half the normal windings and half the number of poles. This construction has still another advantage. We may cross-connect, or rather exchange the electric junctions of the one rotor for the other stator winding, namely: if we connect directly the right-hand rotor winding to the left-hand stator winding, both forming, therefore, a short-circuited winding without slip-rings, and may be former wound. The second half of the secondary winding is on the right-hand stator and may, therefore, be ended at fixed terminals. The stator may be connected to a three-phase starter. The motor has, therefore, no slip-rings, and is eminently suitable for use in fiery mines.

Much depends, of course, on the regularity of the pumping. If the flow of water to be removed is constant, then the pumps can be run direct from the mains of a power-station. In small pumping-plants, if the flow varies very much, the pumps may stand idle during the hours of less flow, but with large installations this is hardly practicable. In the latter case, the pumping-plant must have its own electric generating-plant at the power-station, namely: its own dynamo and spare plant, so as to regulate the speed of the pump by influencing the generator-field through a separate exciter, and also the steam-engine speed. This ensures a speed-regulation without incurring the losses of a speed-control through resistances. This arrangement is only, however, to be recommended for large pumping-plants (300 to 500 horsepower) as the generator-units in the power-station will be about that size. In both cases, however, employing either a separate dynamo or direct driven from the mains, there should be a starting arrangement in the mine as well, and the motor should be provided with slip-rings. In case of emergency, the man in the pump-room should not be obliged to ring up the power-station, but he should be able to shut down the pumping-plant himself. A telephone should always be installed between the pump-room in the mine, which is used at the same time as a general distributing room for the electrical energy, and the power-station on the surface.

The pump-room, in the mine, should be built of stone or brick, and as near as possible water-and-gas tight, even in mines which are supposed to be exempt from fire-damp. This brick-chamber must be well ventilated and lighted, and serve at the same time as a distributing-station for the entire colliery, from which the cables to the various workings will radiate inbye.

FIG. 4. TEMPORARY UNDERGROUND ELECTRIC PUMPING PLANT: THE CENTRIFUGAL PUMP WILL RAISE 220 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 328 FEET, AND THE MOTOR RUNS AT 1,450 REVOLUTIONS PER MINUTE.

This may seem expensive and wasteful, but the writer has found it to be a saving in the end, as it is so much easier to keep the electric and pumping-plant in perfect order, and therefore to economize in repairs and minimize the chance of a breakdown. The longer life of the machinery and of the switch-gear are also advantages not to be overlooked.

If the mine is fiery, the switch-gear should be of the gas-tight enclosed type, in the case of starters of the liquid type, while switches and fuses, if any, should be of the oil-type. The short-circuiting contacts of the liquid starters should be enclosed, and the starter itself provided with a dash-pot, so as to prevent it from being put in or opened too quickly. The switch-gear should be protected from accidental contact on the part of the workmen, although the pump-room should be closed to them.

A central telephone-station should be installed, so as to enable the electrician in the pump-room to be warned in time if any acci-

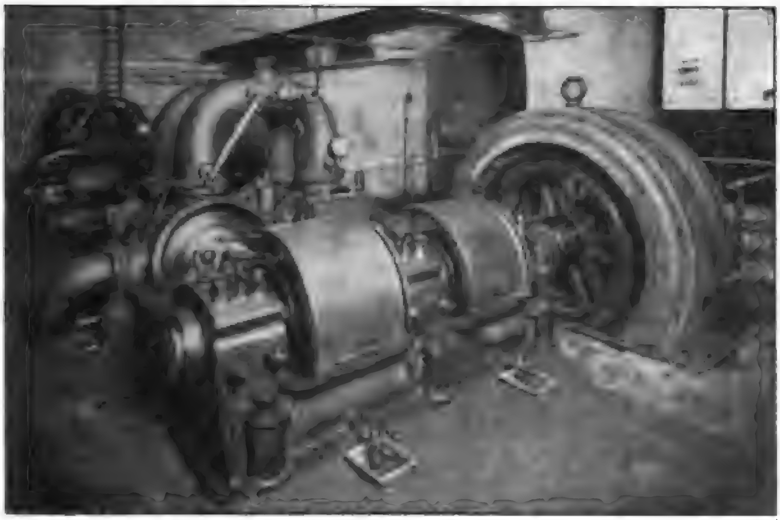

FIG. 5.—UNDERGROUND ELECTRIC PUMPING PLANT AT THE NEU-ISERLOHN COLLIERY: THE TWO RIEDLER EXPRESS PUMPS WILL EACH RAISE 400 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 1,350 FEET, AND THE TWO MOTORS EACH OF 200 HORSEPOWER, AT 2,000 VOLTS, RUN AT 180 REVOLUTIONS PER MINUTE.

dent should occur inbye. The instruments must be made of a strong pattern, of the ironclad type, without flexible connections.

A travelling hand-crane should be provided for inspection and repairing purposes. With high-pressure centrifugal pumps, the dimensions of the pump-room may be much smaller, and it is the writer's conviction that for underground pumping the centrifugal high-pressure pump coupled to a three-phase induction motor, is the best combination that can be obtained and is bound to replace even modern steam-pumps (Fig. 4).

As already mentioned, the induction-motor is much better suited for driving pumps than the direct-current motor, especially if run at a high speed, although it is now quite possible to construct induction-motors with an efficiency of over 92 per cent. running at a speed of 70 to 80 revolutions per minute.

An electric pumping-plant of the three-throw type, capable of raising 1,250 gallons per minute to a height of 1,200 feet, was recently installed at the Kaiserstuhl colliery, Dortmund, driven by an induction-motor of 570 horsepower at 78 revolutions per minute, and taking current at 2,000 volts and a frequency of 22½ cycles per second. The motor was of the flywheel type, in order

FIG. 6.—UNDERGROUND ELECTRIC PUMPING PLANT AT THE RHEIN-PREUSSEN COLLIERY: THE SLOW-SPEED THORIS PUMP WILL RAISE 1,250 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 1,500 FEET, AND THE MOTOR OF 650 HORSEPOWER, AT 2,000 VOLTS, RUNS AT 60 REVOLUTIONS PER MINUTE.

to provide against the uneven torque required for driving the pump, and the slip was therefore about 3 per cent. at normal load. The starting torque required was about 20 per cent. higher than the full-load torque, and this is the chief difficulty in designing induction-motors running at such slow speeds, owing to the magnetic leakage due to the great number of poles.

Motors of this size are provided with slip-rings, enclosed gas-tight, and with an arrangement to lift the brushes, and short-circuit the windings, when full speed is obtained.

Another modern pumping installation with high-speed Express pumps is placed in the Mansfeld copper-mines at Eisleben. It comprizes four Riedler Express pumps, each having a capacity of 1,250 gallons per minute, with a head of 1,305 feet. They are driven by four induction-motors of 650 horsepower, running at 160 revolutions per minute and 3,000 volts.

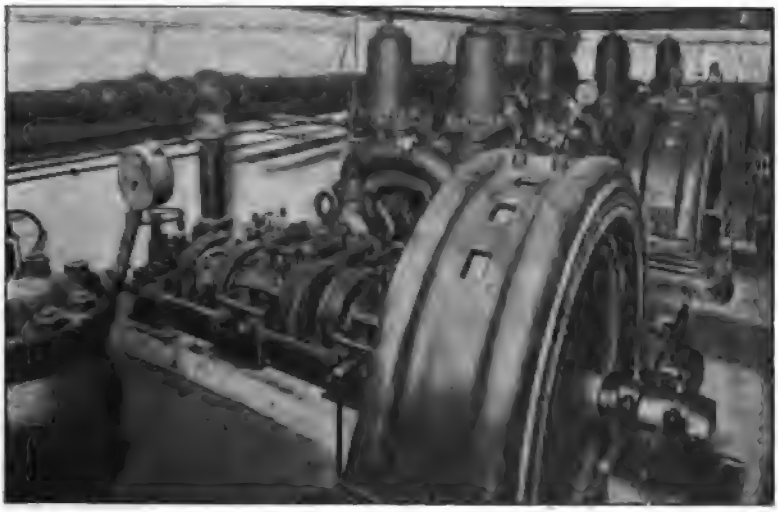

FIG. 7.—UNDERGROUND ELECTRIC PUMPING PLANT AT THE COLONIA COPPER-MINE: THE FOUR RIEDLER EXPRESS PUMPS WILL EACH RAISE 1,100 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 1,350 FEET, AND THE FOUR MOTORS EACH OF 650 HORSEPOWER, AT 3,000 VOLTS, RUN AT 160 REVOLUTIONS PER MINUTE.

Other large modern pumping plants are shown in Figs. 5, 6, 7, 8 and 9.

Comparison with Steam-pumps.—In order to show clearly the many advantages of electrically-driven pumps placed at the pit-bottom, it may be useful to discuss the claims which conservative mining engineers set up against the electric motor as compared with the steam-engine. A common complaint is that, what is gained by using a slow-speed pump is lost again in the high price of the slow-speed motor. As already pointed out, the pump-makers

have arrived at a speed for highly efficient pumping machinery (88 per cent. of efficiency) varying between 100 and 200 revolutions per minute: this speed being high enough to enable the electrician to design an efficient electric motor at a reasonable price. This, of course, does not refer to centrifugal pumps, running at speeds which require a cheap electric motor.

Another remark which is often heard is that the electric motor cannot be flooded. Of course no one will claim for the electric motor, at least of any size, that it can work under water for any considerable length of time: this performance being also very difficult for a steam-engine.

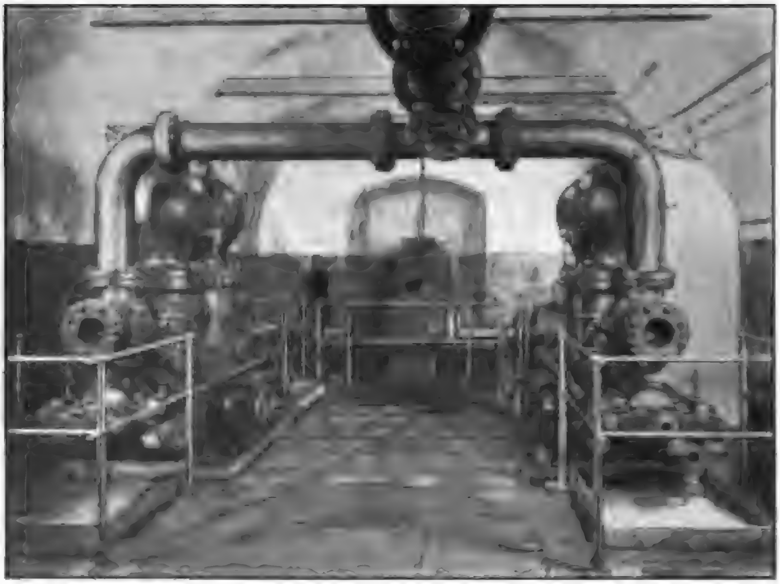

Fig. 8.—Underground Electric Pumping Plant at the Czernitz Colliery: the Express Pump will raise 780 Gallons of Water per Minute to a Height of 825 Feet, and the Motor of 260 Horsepower, at 750 Volts, runs at 175 Revolutions per Minute.

Sinking pumps can be made to work under water for any length of time, and are then in a very much better position than a steam-pump, as the useful cooling effect of the water, in the latter case acts as a condenser. But there should always be sufficient spare pumping-plant at a mine to cope at any time with an increased volume of water, caused by one of the many mishaps which do occur in mines. If, therefore, the pump-room

be constructed in such a way as to be practically water-proof for at least 3 or 4 feet above the bottom-level, sufficient time will be afforded, in most cases, to lower the water-level, by means of the spare pumps, before the water can enter the pump-room.

With electric pumps it is possible to run them from a central power-station, and to start or shut down in a few seconds without first communicating with the primary power-producing plant. With steam-pumps, it is of course also possible to run several pumps from one battery of boilers; but, in the latter case, the whole of the long steam-range must be kept under steam, which is a most wasteful process, and has many additional disadvantages, such as heating the shaft.

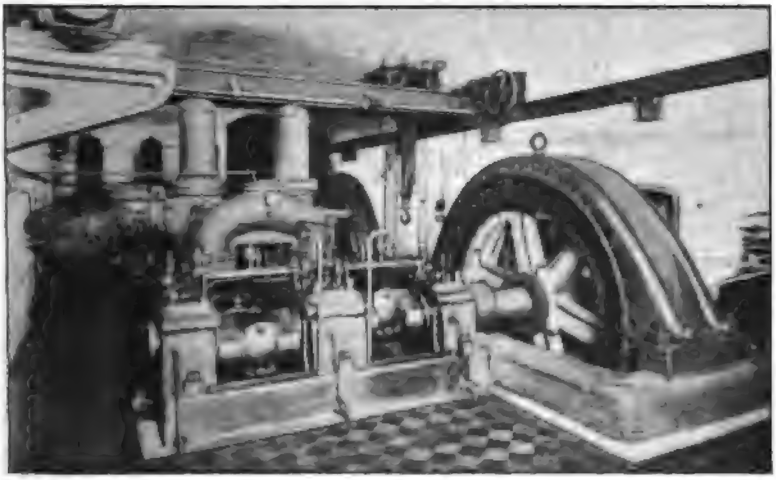

FIG 9.—UNDERGROUND PUMPING PLANT AT THE ENGELSBURG COLLIERY, BOCHUM: THE TWO RIEDLER EXPRESS PUMPS WILL EACH RAISE 550 GALLONS OF WATER PER MINUTE TO A HEIGHT OF 1,800 FEET, AND THE MOTOR OF 700 HORSEPOWER, AT 2,200 VOLTS, RUNS AT 200 REVOLUTIONS PER MINUTE.

With hydraulic pumping-plants, when starting or shutting down any pumps, the speed of the pressure-pump must be regulated in the hydraulic station at the mouth of the mine.

Electric pumping is therefore more flexible, and requires less spare plant, as in a central electric power-station a reserve is kept for the whole of the electric mining plant. It is also possible to erect the central power-station on the most suitable spot, and not necessarily near the mouth of the mine, as is required by steam-plant, in order to have the boilers near the

have arrived at a … (88 per cent. of e… per minute: … trician to de… This, of co… speeds w…

… the biggest steam-user. Several incidental … be added, namely, the absence of steam-pipes in … when they are inconvenient and damage the shaft-… and the electric cables may …ken down the upcast-shaft as well as down the downcast-shaft, without interfering with the ventilation.

Ano… motor elect… for ve…

Working Costs.—*In the first* place, it may be reckoned that *a modern electrically-driven* pump does not cost more than a *steam-pump. Centrifugal* electric pumps cost even less. Therefore, *the figures for sinking*-fund and interest on capital outlay *are not more, and if the* cables are set against the steam-pipes, *certainly less, than* with steam-pumps. In the second place, the *repairs of the motors* and cables are practically *nil*, and compare *very favourably* with those of the steam cylinders and pipes of a *steam-plant.* Further, the most important item in the working-*cost figures,* is the amount of power taken by the pump; and, *therefore,* also the efficiency.

Efficiency.—The losses caused by condensation of the steam *in the pipes* during stops are entirely avoided. When running, *the combined* efficiency of the pump and the motor is about *the same* as that of a steam-pump. The same statement holds *good* if a centrifugal pump is used, as in the latter case, the higher motor-efficiency partly equalizes the lower efficiency of the centrifugal pump. The chief savings are of course effected in the electric station, where an economical high-speed condensing engine may be used, having a much higher efficiency than the pipes and boiler-plant used in running a steam-pump.

A practical average value for an electric pumping-plant of medium size, calculated by the writer from observations of fifteen large electric plants, is 65 per cent. from the steam side of the main engine to the water raised by the pump. This represents from 16 to 18 pounds of steam per horsepower-hour of useful load, an efficiency which is not often reached with steam-pumps.

The individual efficiencies of the different sections of the machinery have been determined, and also constitute a fair average taken over a number of installations, namely, engines, 88 per cent.; dynamos, 93 per cent.; cable, 97 per cent.; motor, 90 per cent.; and pump, 86 per cent.

The efficiency of the Express pump is the highest, rising to

95 per cent.: this figure being the efficiency of the 500 horse-power Riedler pump at the Hausemann colliery. Other Express pumps show from 90 to 92 per cent. of efficiency.

Centrifugal pumps have a lower efficiency, being about 75 per cent. for Sulzer-type pumps, and 80 per cent. for Rateau-type pumps; but their motor-efficiency is about 4 to 5 per cent. higher, so that at the best, the total combined efficiency is always about 5 per cent. less. The larger the capacity, however, the nearer the efficiencies of the two kinds of pumps approach each other.

The lower costs, however, of the combination-motor and pump, the lower repairs and maintenance-costs, the smaller space and security against breakdowns, are well worth the lower efficiency.

Electric Sinking-pumps.—The conditions under which sinking-pumps must be calculated to work are entirely different from stationary pumps, and therefore they have to fulfil other requirements. Moreover, very little has as yet been done in this particular branch, for which the adoption of electricity possesses some very marked advantages.

Sinking-pumps may be divided into two kinds, (1) one requiring both engine and pump to be slung in the shaft; and (2) where the engine is mounted on the pit-bank, and drives the pump through shafting and rods. The latter kind is the heaviest and most expensive, and is only used where water-bearing strata of quicksand have to be overcome. In this case, large quantities of sand and other impurities have to be lifted by the pump, which would destroy the ordinary high-speed ram-pump with metal valves, in no time, while the slow-speed rod-driven pump fitted with leather or rubber-valves is not much damaged by the sand.

Steam is generally used, and the disadvantage of steam-pumps for sinking purposes are only too well known. There is the low efficiency and the difficulty in ventilating the shaft-bottom and the shaft itself, the room taken up by frequently leaking steam-pipes, which even obstruct the shaft to such an extent, as to prevent the sinkers from doing their work efficiently.

All these disadvantages disappear at once with the introduction of electricity, and one wonders why any steam sinking-pump

is still used. One of the reasons is, that ram-pumps driven by an electro-motor through gearing, are not only heavy and cumbersome combinations (not more so, however, than steam-pumps) but are also more expensive. It is difficult to render the motor water-tight; and, altogether, when comparing them with pulsometers, where low lifts are concerned, the disadvantages of the steam-pump are forgotten in face of the high cost of the electric pump.

Fig. 10.—Vertical Electric Sinking Pump at the Aix Iron-works: the Centrifugal Pump will raise 750 Gallons of Water per Minute to a Height of 300 Feet, and the Motor of 100 Horsepower runs at 1,450 Revolutions per Minute.

The introduction of the high-pressure centrifugal pump, with its simplicity, small dimensions, lightness and high speed, has altered the case, and the writer contends that an electrically-driven centrifugal pump is unrivalled for sinking purposes on all points.

The compact design and small dimensions of the electric sinking pump are readily recognized. The construction, though simple, must be carried out in a very thorough manner, and the writer is glad to say that many have now been built on the Continent which yield excellent results.

The motor, mostly three-phase, turns round a vertical axle and must, therefore, be carefully balanced and protected from the dripping water. The weight of the rotating part is carried on a ball-bearing protected by a tightly-closing hood, which also encloses the starting device. The lower bearing is formed by the stuffing-box of the centrifugal pump. The pump-axle is made in one with the motor-shaft, and is supported on another bearing

fixed in the pump-casing. The bottom part of the motor-casing is shaped in such a way as to form one with the pump, without, however, preventing access to the stuffing-box. The top part of the motor-casing protects the motor against any water-spray. The windings are, of course, extra-insulated, so as not to suffer from dampness in the shaft. The starting device is mounted on the pump, as it is found better to stop and start the pump in the shaft at will, without signalling to the surface. The simplest device is the centrifugal automatic starter, which may be used with motors up to 100 horsepower and can be easily enclosed so as to be air-and-water tight. For powerful pumps, in cases where variations of the voltage are not allowed, starting resistances must be used (Fig. 10).

The pressure and suction-pipes are doubled, while the suction-pipe enters the pump from above, thereby partly doing away with the pressure due to the weight of the rotating masses. This arrangement practically removes all pressure from the ball-bearing.

The entire pumping-set is slung on two chains, hooked into the eye-bolts, which connect the top and bottom parts of the set. The pump-motor and pipes are kept rigidly in line through being connected to the covering of the motor. A steel protecting hood covers the whole pump, and under it are mounted the various regulating appliances, namely, an ammeter, a starter, a main switch, and the stop-valve hand-wheel.

These pumps have a compact and mechanical appearance, and their advantages are calculated to bring them into use in a short time.

The President (Mr. John Gerrard) said that he had seen a large installation of electric pumping machinery in Westphalia, and had the advantage of comparing its work with that of the old steam-pumping plant, which it superseded. He especially noted that the electric installation occupied only one-half the space taken up by the steam-plant, whilst doing the same amount of work.

The cordial thanks of the meeting were given to Mr. Hooghwinkel for his paper.

The discussion was adjourned.

MANCHESTER GEOLOGICAL AND MINING SOCIETY.

EXCURSION MEETING,
JULY 22ND, 1905.

The members visited the Little Don Valley Water-works, in course of construction by the Sheffield Corporation, under the leadership of Mr. William Watts, Assoc.M.Inst.C.E., F.G.S., engineer of the works.

LITTLE DON VALLEY WATER-WORKS.

The Underbank reservoir, near Stocksbridge, was being made to impound water for purposes of compensation only. The reservoir, when full, is estimated to hold 650,000,000 gallons of water and to submerge 100 acres of land; and the drainage-area flowing into it is 2,336 acres in extent. The length of the embankment is 1,560 feet, and it contains 350,000 cubic yards of earth and puddle. The trench, belowground, forming the foundation for the concrete-core, is 71 feet deep on an average, and is refilled with cement-concrete.

There are a discharge tunnel, 14 feet in diameter, built in the solid on the southerly side; a valve-well, 11 feet in diameter; a waste-weir, 250 feet in length; and a bye-wash, 50 feet wide, formed of ashlar steps in risings of 15 inches from the bed of the river to the top water-level.

The total drainage down to the embankment is 8,698 acres, and the estimated rainfall is 48 inches.

The average elevation is 835 feet above Ordnance datum-level, assuming that the hills were levelled into the valleys represented by the 2,336 acres.

The old highway, which formerly ran in what is now the reservoir-bottom, had been diverted, and a new one formed, 1½ miles long, terminating at Midhopestones; and, in order to facilitate the haulage of goods, a tramway had been constructed, 3½ miles in length, to enable the materials required for the works to be conveyed direct from Deepcar station on the Great Central Railway.

The surface-geology of the valley is less interesting than its physical features. The upper measures are covered with local débris, denuded from the slopes by the eroding agencies of time, without any admixture of foreign matter indicating a glacial period, or even a submergence beneath the sea since the hills emerged above it, in time too far back for the human mind to measure it with a degree of accuracy sufficient to be understood. No boulders or boulder-clay have been found to mark the boreal conditions of an Arctic climate, such as one finds on the other side of the Pennine ridge in the Lancashire valleys.

The superior strata in which the trench has been cut are in the Lower Coal-measure series, and two seams of coal have been met with at the northerly end, but denudation has removed them from the southerly side of the valley. A fairly large fault was cut through at the northerly end, lifting the measures up on the southerly side, and thus protecting the outcropping edges of the parent beds, which plunge under Penistone.

The Little Don river has a gradient of 1 in 40, from its confluence with the Don at Deepcar to the crest of the Pennine range, a distance of 7 miles. The hills in places attain an altitude of 1,700 feet, and all the way the river is verged by trees.

At Langsett, there is a fine view of the winding course of the Little Don, and in the distance overlooking Stocksbridge, Wharncliffe Crags are seen as beacons of serried rocks, illustrating evidence of hill-erosion. The threshold of the Pennine Chain is here reached, and the slopes rise to the crest in unbroken sequence, which gives a moorland view of rare beauty. The average elevation of the land down to the centre-line of the embankment is 1,281 feet: the zone on which rain-gauges should be placed, so as to obtain a true average of the annual rainfall.

The watershed controlled by the reservoir is 5,203 acres in extent. The floor is fairly impervious, and no important springs exist upon it. In flood-time, the water is of a peaty colour, but the contributory streamlets carry very little denuded material, as the water slides along mainly on indurated channels, which resist wear-and-tear of the ground.

The Langsett reservoir covers 124 acres, and holds 1,400,000,000 gallons. The length of the embankment is 1,144 feet, and it contains about 900,000 cubic yards of earth and

puddle. The roadway passing over it is 817 feet above Ordnance datum-level. The concrete trench on which the puddle rests is 1,648 feet long, with an average depth of 91 feet below the floor of the valley; the material removed amounts to 47,500 cubic yards, and the excavation has been refilled with 43,000 cubic yards of cement-concrete. The puddle-trench contains 69,500 cubic yards of clay.

The discharge-tunnel is 9 feet in diameter; and the circular valve-shaft is 12 feet in diameter, 100 feet in depth, and contains six valves, 33 inches in diameter, all of which are worked by hydraulic cylinders.

The shale, in which the concrete core is embedded, lies immediately under the rough rock of the Millstone Grit, and attains a thickness of about 200 feet. It yielded a prolific supply of water when first opened out, but does not admit it as spring-water at the surface, the ducts not leading upwards as they do along the bedding-planes. On the south side, the shales are shattered above the floor of the valley, and present innumerable slip-joints, some of which were open, but these lines of fracture do not extend more than a few feet below the solid floor of the river and disappear in the heart of the hill. To get rid of these open joints, the trench was opened to a depth of 170 feet below the ground-level, and carried about 200 feet farther into the hill than the end of the embankment.

The measures in the centre of the valley were found to be a little wavy, but the contorted beds died away in curiously twisted foldings, solidly filled with impervious matter, growing thinner and thinner as they were deepened and finally died away in normal bedding.

The valve-tower on the embankment, the waste-weir, 200 feet in length, the bye-wash, and a stone-arched bridge represent the class of masonry and work carried out in the Little Don valley.

THE RE-OPENING OF HARTLEY COLLIERY.*

BY R. E. ORNSBY.

In 1862, the main beam of the pumping-engine at the Hester pit, Hartley colliery, broke in the middle. One half fell down the shaft and only outlet and closed it, and 199 men and boys were entombed. Their bodies were reached after 10 days, but unfortunately in all life was extinct. They had probably been suffocated by carbon monoxide from the ventilating furnace.† A result of this catastrophe was the legal enactment that every mine must have two shafts or outlets.

The shaft was only re-opened so far as was necessary for the recovery of the bodies. The lease of the royalty was given up by the then lessees, and acquired by the Seaton Delaval Coal Company, who in 1872 to 1875 sunk two shafts to a depth of 384 feet, the Hastings and downcast pit for coal-drawing and water-pumping, and the Melton and upcast pit. The shafts are 120 feet apart and about 2,000 feet north of the illfated pit (Fig. 1, Plate XXV.).

The Yard coal-seam, at a depth of 336 feet in the shaft, then commenced working and had (except for a short interval) continued in operation ever since. The narrowing of its limits made it necessary in 1894 to sink to a further depth of 168 feet and to work the Low Main seam.

The shafts were sunk and places holed round, and south headings were driven in order to hole into the old workings. Fig. 2 (Plate XXV.) shews the position of the Hastings, Melton and Hester shafts, and the two headings. The old workings in the Low Main seam of the Hester pit, and of the Mill pit (an older winning than the Hester pit) are connected by a drift and a bore-hole at E (Fig. 1, Plate XXV.).

A communication was made in 1884 from the Yard seam of the Hastings pit, to the Yard seam of the Hester pit (thrown down by troubles to a further depth of 90 feet), by means of a

* This paper was read and discussed at the General Meeting of The Institution of Mining Engineers held in London on May 29th, 1902.

† *Trans. N.E. Inst.*, 1862, vol. xi., page 143.

drift, F, and a hore-hole, G, so as to run off the water in the disused workings of the old pits above the level of the drift (Fig. 6, Plate XXV.). A valve, *a*, was attached to the top of the pipe, *b*, in the bore-hole in order that the flow might be regulated (Figs. 3 and 4, Plate XXV.). After some years, the level of the water in the Hester and Mill shafts fell to the anticipated depth; and the desired effect of lessening the water in the workings of the Yard seam at the Hastings pit was realized (Figs. 6 and 7, Plate XXV.).

As one could not be certain that the plan of the workings at the Hester pit was correct, and on account of the great possible head of water of 199½ feet (the difference between the level of water in the Hester shaft and the level of the Low Main seam at the Hastings shaft), equal to 86½ pounds on the square inch, it was decided to bore in the south winning places H, I and J, from their outset (Fig. 2, Plate XXV.). At first, the places were driven 7 feet wide, in accordance with the Coal-mines Regulation Act, but as the places advanced, greater precautions were from time to time put in force. When the western place, H, had reached 336 feet, measured from the point on the old plan at which it was intended to make a holing, the eastern place, I, at a distance of 570 feet from the old workings in the same course it had been driven, was stopped, immediately after a holing between the two exploring places had been effected. The western heading, H, at 303 feet from the old workings, was reduced in width from 7 feet to 6 feet, and front-holes were bored to a length of 36 feet; and, after 6 feet of coal was taken off, the hole was again advanced to 36 feet. Consequently, the front hole was never allowed to be less then 30 feet, as a minimum, ahead of the face. Flank holes, 6 feet apart, were drilled to a length of 30 feet, at an angle of 45 degrees to the course of the place. And as an additional precaution, holes, at an angle of 25 degrees, were bored of the same length as the flank-holes, midway between the front-hole and the flank-holes, further holes being bored after 6 feet of coal was taken out (Fig. 5, Plate XXV.). And at 150 feet from the old workings, the front holes were increased in length to 45 feet or longer, and 15 feet of coal was taken off leaving a minimum length of 30 feet of coal, as proved by the bore-hole, in advance of the face.

Little or no water was encountered in any of the holes until January 6th, 1900, when about 8 gallons per minute (as measured)

flowed from a hole, 54 feet long when the rods were in. The pressure-gauge indicated 82½ pounds per square inch, equal to a head of 191 feet of water-column. The point reached by the rods was exactly where the holing was expected to be effected. The diameter of this and all previous holes was 2¼ inches. It was thought that the hole had penetrated into "breaker coal" or a place closely fallen, but it was ultimately found that it had penetrated the roof of an old working-place. The face was advanced 3 feet leaving on 51 feet of hole. On January 11th, 1900, a second hole was bored, with the result that when the rods were in, there was a feeder of 100 gallons per minute; and it was now clear that the hole had holed into the old workings.

No difficulty was experienced from the pressure of water, and the Burnside boring-machine being employed, the simple turning of a tap stopped the flow of water, when desired.*

The rods were withdrawn on January 15th, and the hole was enlarged on January 19th to a diameter of 3 inches and 900 gallons per minute flowed. This hole was further enlarged to 3½ inches in diameter and another hole was bored 2¼ inches in diameter and afterwards widened to 3 inches in diameter. The flow from these holes reached its maximum on March 5th, of over 1,900 gallons per minute, and including 100 gallons from the workings of the Hastings pit, over 2,000 gallons per minute were pumped to the surface. As the discharge of water decreased with the diminishing pressure, the discharge-area was increased by adding to the number of holes and increasing the diameter of the 3 inches hole, mentioned above, to 6 inches. A discharge to give to the engines as much as they could safely pump was maintained as far as possible (Fig. 8, Plate XXVI.).

The water, *a*, in the Hester shaft fell slightly, *b*, on the sinking of the Hastings shaft to the Yard seam. As previously stated, it fell, *c*, on the holing being made by rods from the Yard seam of the Hastings pit. After the connection of the workings in the Low Main of the Hester pit with the workings in the Low Main seam of the Hastings, the water fell to a depth, *d*, of 381 feet from the surface. The plummet was stopped by some obstruction at this level, probably some of the débris derived from the collapse of the shaft at the time of the fall of the half-beam (Fig. 6, Plate XXV.).

After the Hastings pit was sunk to the Yard seam, the water in the Mill shaft stood at a depth, *b*, of 94 feet below the surface.

* *Trans. Inst. M. E.*, 1902, vol. xxiii., page 74.

After the holing by the rods from the Yard seam of the Hastings pit, the water was lowered in the shaft to a depth, *c*, of 245 feet, and since the connecting of the workings in the Low Main seam of the Hester and Hastings pits the water was followed by the plummet to a depth, *d*, of 259 feet from the surface, when some obstruction stopped the further progress of the plummet (Fig. 7, Plate XXV.).

The normal quantity of water pumped for some years previous to the holing in the Low Main seam was 575 gallons per minute—475 gallons being derived from the drift at the Hester pit and 100 gallons from the workings in the Yard and Low Main seams of the Hastings pit. The feeder flowing through the drift in the Yard seam from the workings of the Hester pit soon ceased after the holing was affected in the Low Main seam.

When it was obvious that the water had been lowered in the old workings of the Low Main seam to the level of the bore-holes (the flow had by this time been reduced to 1,200 gallons per minute), the exploring-place, 6 feet in width, was advanced to 7 feet from the point of contact of the rods with the old excavation, and the place for this further distance of 7 feet was driven 18 inches wide to A (Fig. 2, Plate XXV.). There was only a slight temporary increase in the quantity of water after holing with the picks; and this was due to excavating the bottom of the place to a lower level than the holes. The old place, then entered, was upstanding, as was also a stenton nearly opposite, and the second parallel place. These places had been used as water-levels. It was, however, found impossible to travel towards the main area of the old workings owing to the water touching the roof in a "swelly."

The other parallel exploring drift was bored and advanced, and it also holed, at B, into the same water-level (Fig. 2, Plate XXV.). On account of the inclination of the exploring-place, and the eastward dip of the seam it was determined to drive forward another parallel heading, J, which holed at C into one of a pair of dip headings. It may be mentioned that this place also was bored. This last drift from the Hastings shaft allowed a somewhat easy entry into a large number of old places. The main body of water was directed into it so as to allow the two headings, H and I, to be completed, the middle one for a haulage-road and the westernmost for a return-airway.

The timber in the old workings was found in an excellent state of preservation. Cast-iron pipes were covered by a thick incrustation of iron oxide, in which shale and coal were imbedded,

and cast-iron tub-wheels were similarly incrusted. Wrought-iron rails and picks, and all parts of tubs made of wrought-iron were also incrusted, but unlike cast-iron, the wrought-iron had been diminished in size, being partially eaten away, while the cast-iron was altered in its nature and looked like indurated clay. Harness and leather tokens were found in a good condition. The bones of horses lying in the mud and water were easily detected, when exploring, by the unpleasant odour emitted on their being disturbed.

The coal-pillars are scarcely deteriorated either by pressure or water. What have been sidings, and the walls at bord-ends, are more or less fallen, sometimes heavily.

The old workings, in the area comprized between the lines connecting the points, A, B, C and D, had been used as a standage for water, in case of a stoppage of the pumping appliances (Fig. 2, Plate XXV.). They were all situated below the level of the point D on the old main (and what will again be a) rolleyway. The haulage-road from this point rises inbye, and the road dipped outbye to the shaft (Fig. 6, Plate XXV.), and the dip towards the shaft from D, had been utilized to work syphons. From the point, D, the places approaching the Hester pit cannot be penetrated beyond a few feet owing to their being full of water.

The water from the old workings of the Hester pit, after gradually decreasing, has remained stationary since about the end of 1901. The total quantity now being pumped from the present and the old workings is about 625 gallons per minute.

The water from the Yard coal-seam was pumped from a sump, 48 feet below that seam. The Hathorn-Davey compound condensing pumping-engine on the surface, with cylinders, 22 inches and 44 inches in diameter respectively and 7 feet stroke, actuates, by a quadrant and spears, 14 inches square, two rams each 17½ inches in diameter. The rising main of cast-iron pumps were 15 inches in diameter. The pressure of the steam at the boilers was 50 pounds per square inch.

This engine has been replaced by another Hathorn-Davey compound condensing pumping-engine, erected in the same house, to meet the increased depth of 168 feet to the bottom of the sump in the Low Main coal-seam. The cylinders are 38 inches and 68 inches respectively in diameter and 7 feet stroke. The pressure of the steam at the boilers is 80 pounds per square inch. The old quadrants and spears were utilized. The old cast-iron rising

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main was replaced by steel tubes 18 inches in diameter. This pumping-plant has forced 1,500 gallons of water per minute to a height of 552 feet, from the sump in the Low Main coal-seam to the delivery-drift at the surface. This engine, if supplied with steam from the boilers at a pressure of 100 pounds per square inch, would drive two rams, each 20 inches in diameter; it was deemed advisable, in order to meet eventualities, to erect an engine much larger than was actually necessary; the cost being very slightly enhanced. Should a larger quantity of water be encountered, or the quadrant, etc., fail by age, they would be replaced by quadrants, spears and rams of larger dimensions.

An Evans high-pressure pumping-engine, with two cylinders, each 26 inches in diameter and 3 feet stroke, and two rams, each 10 inches in diameter, was placed in the Low Main coal-seam. The rising main of steel tubes is 10 inches in diameter. The engine, used as an auxiliary to the surface-engine, was of much service in the drainage of the old workings; and it had pumped 800 gallons of water per minute.

Prof. R. A. S. Redmayne (Birmingham) said that the paper was of peculiar interest to himself, as at the time when the exploratory workings were being carried out he was associated with Mr. Ornsby in the re-opening of the colliery. The operations included the very difficult sinking of two shafts from the Yard seam to the Low Main seam. This was successfully accomplished without cessation of coal-drawing, and during the whole of the time, extending over 3 years, only one accident occurred to one man through a blown-out shot. The pumping-plant was probably one of the largest in Northumberland, and for some time 2,000 gallons of water were pumped per minute. The Burnside safety-boring apparatus was used continuously, in every bore-hole. Various materials were found in an extraordinary state of preservation on re-opening the seam. Thus, it was interesting to know that the baulks of timber had been so preserved that they were still being used to support the roof, and Mr. Henry Richardson, who was down the pit recently, had informed him that what was there demonstrated naturally was being carried out by artificial means at Ashington, namely, the preservation of timber by brine.* On cutting one of the baulks of timber, 8 or 9 inches

* *Trans. Inst. M. E.*, 1896, vol. x., page 531.

square, it was found to be perfectly preserved to about ¼ inch from the surface. All iron materials were much corroded and coated with various kinds of accretions, but chiefly carbonate of lime. The iron itself was completely changed: it was as light as brown paper, and looked like graphite. There was no accretion on any kind of leather or wood.

Mr. T. E. FORSTER (Newcastle-upon-Tyne) said that he was down the Hartley pit when the explorations were being made. The experience with regard to cast-iron was exactly the same as they met with at Wallsend colliery, a pit which had been under water for about 40 years. The haulage-ropes used at Hartley in former days, seemed to have been made of hemp protected with iron wrapping or armour on the outside—something like an armoured cable. It was extremely interesting to visit a pit, in which all the remains of the tubs, ropes, inclines, ponies, etc., could be seen exactly as they had been left at a moment's notice, 40 years ago. There were two shafts, for a portion of the depth, and all the workmen and boys had made their way up to the furnace in the Yard seam, where the whole of the bodies were found. They were evidently suffocated by fumes, and for the same reason it was not possible to get down the shaft to save the men, owing to the fumes passing through the loose stones and timbers which filled the shaft.

Prof. REDMAYNE said that the late Mr. George Baker Forster was chiefly instrumental in recovering the bodies out of the mine after the accident. The water in the Hartley royalty was as nearly as possible a saturated solution of salt, and it was probably derived from the sea. It was possible that the Low Main seam might be eventually worked under the sea.

Mr. C. C. LEACH (Seghill) said that he was working the Yard seam at a colliery adjoining Hartley, and the water was not at all salt.

Mr. T. E. FORSTER (Newcastle-upon-Tyne) said that, curiously enough, all along the sea-line salt-water was met with in the Low Main seam. At Cambois colliery, where they were working a little more than ¾ mile out to sea, the only fresh water found in the pit occurred ½ mile under the sea, which showed what a long way the water must have travelled through the strata.

Prof. REDMAYNE said that, in the Yard seam, at Hartley colliery, he remembered seeing at a spot within 600 feet of the sea, two feeders, one in the thill, very salt, and one in the roof, of fresh water. He believed that the water-feeders in the workings of old Hartley pits were derived from the sea. The salt-water had a destructive effect on the ironwork of the pumps.

Mr. W. B. WILSON, jun. (Wheatley Hill Colliery) asked whether the original bore-holes, 2¼ inches in diameter, were enlarged to 3 inches and more, through the Burnside apparatus; or whether the Burnside apparatus were first withdrawn, and what precautions were then taken to control the outflow of water. The preservation of the timber and leather would probably be due to the water being salt. The timber in the old workings in the Harvey seam of Thornley colliery was found very well preserved, after having been under water which was rather salt, about 4 years longer.*

Mr. SYDNEY F. WALKER (London) thought that the action of the salt-water on the iron was an electrical one. Wrought-iron was almost pure, and if oxygen were present in any form for which the metal had an affinity it simply ate away the iron. In the case of cast-iron they had practically an alloy of iron and carbon, the carbon being in very much greater quantity than in wrought-iron. It must be borne in mind that time was a factor of great importance. In this case, the lapse of time was considerable and he thought in the cast-iron they would have iron and carbon in a more or less mechanical mixture, with other things. This dirt was partially dissolved out, and they had the salt-water getting in between the carbon and the iron, forming at once a galvanic battery. The iron became oxidized, and other actions following between the new substance and the carbon produced gradually another substance which had been described as indurated clay. He had pleasure in proposing a vote of thanks to Mr. Ornsby for his interesting paper.

The PRESIDENT (Mr. J. S. Dixon) seconded the resolution, which was cordially approved.

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* *Trans. Inst. M. E.*, 1902, vol. xxiii., page 79.

APPENDICES.

I.—NOTES OF PAPERS ON THE WORKING OF MINES, METALLURGY, ETC., FROM THE TRANSACTIONS OF COLONIAL AND FOREIGN SOCIETIES AND COLONIAL AND FOREIGN PUBLICATIONS.

URANIUM-ORE DEPOSIT IN AUVERGNE, FRANCE.

Sur un nouveau Gisement uranifère français. By E. Boubée. *Bulletin de la Société française de Minéralogie*, 1905, *vol. xxviii., pages* 243-244.

The author has quite recently discovered and investigated this deposit, situated in the neighbourhood of Ambert, in the department of the Puy-de-Dôme. It consists of a ferruginous vein, from 20 to 26 or more feet thick, which has been traced for ¾ mile at least. At the base, in a much altered ferruginous quartz, magnificent crystals of chalkodite and uranite occur in fissures, comparable with the best examples of the kind known from Saxony, Cornwall, Spain, and elsewhere; also films of uranium-ochre are noted. The vein appears to become richer the deeper down one goes: thus, the samples got from 13 feet below the surface are at least thrice as rich as those obtained from the outcrop. In the same quarry there occurs also a vein of mispickel, partly crystalline, associated with blende in a gangue of altered protogene. L. L. B.

RADIO-ACTIVE MINERALS IN FRANCE.

Sur un nouveau Minéral radifère. By J. Danne. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1905, *vol. cxl., pages* 241-243.

The author lately discovered that certain plumbiferous rocks of the neighbourhood of Issy-l'Évêque, in the department of Saône-et-Loire, contain radium. The element is more especially associated with the pyromorphite, the other radio-active substances in the deposit being plumbiferous clays and pegmatites. The remarkable circumstance is that none of them contain uranium, whereas hitherto it had been supposed that radium was only present in uraniferous minerals. And thus the facts appear to be in contradiction with the hypothesis that radium is really a derivative of uranium; it is possible, however, that the radium has been quite recently introduced into the pyromorphite by the percolation of radio-active waters. The lead-ore occurs in the form of narrow veinlets seaming quartzose and felspathic rocks, which are always very damp, owing to the presence in the neighbourhood of numerous springs. The waters from these go by preference to the plumbiferous rocks (as these constitute the most permeable soil of the district), and radio-active gases are shown to be in solution in them.

A radium-bearing mineral has also been found at St. Symphorien de Marmagne, 25 miles away.

Some of the specimens of the Issy pyromorphite exhibit a radio-activity

which is equivalent to that of uranium several times multiplied; but, as a rule, the radio-activity is much feebler. The size of the deposit is sufficient to allow of the extraction of salts of radium on an industrial scale.

L. L. B.

MANGANESE-ORE IN THE BLACK FOREST, BADEN.

Die Manganerz-Vorkommen im oberen Schwarzwald, Grossherzogthum Baden. By JOSEF LOWAG. *Österreichische Zeitschrift für Berg- und Hüttenwesen*, 1903, *vol. li., pages* 146-148.

In the mountain-system of the Black Forest, the prevailing rocks are crystalline schists, gneiss and granite. The rock is much fissured, and the fissures, especially in the southern and higher parts of the mountains, are filled with lodes of various ores. The granite runs north-east and south-west down to the Rhine, thinning off on the north-east where it disappears under a layer of variegated sandstone. The distinguishing features are the occurrence of oligoclase and orthoclase, and the porphyritic structure of the granite. Groups of mineral lodes running north-west and south-east intersect the granite, and form, especially in the later coarse-grained granite, a rich deposit of silver- and cobalt-ores, barytes, and copper-pyrites. Red hæmatite and manganese-ores are also found, sometimes in parallel, sometimes in cross-courses. Formerly the whole district was extensively worked for all these minerals, as evidenced by the numerous waste-heaps and abandoned mines, but the rock being hard, and the lodes thin, working was probably never profitable.

Red hæmatite and manganese-ores occur chiefly in dark red felspathic granite; the brown iron-ore also shows traces of manganese, and is easily smelted. The iron- and manganese-ores are always found together in the granite; the former is mixed with felspar, which detracts from its value for smelting, but the manganese-ores are pure. They consist chiefly of manganite, fibrous manganese and pyrolusite. Neither the red iron-ore nor the manganese-ore extend to a great depth: the manganese-ore thins out at 65 to 80 feet, while below 130 feet the red hæmatite passes over into copper- and cobalt-ores. Small quantities of porphyry occur with the granite in various places, and are sometimes traversed by lodes of felspar containing manganese-ore and brown hæmatite.

Manganite, compact, streaky or crystallized, and pyrolusite are the prevailing ores, and, in others, philomelane. With these minerals, felspar, white and pink, in great abundance, fluorite, quartz, jasper, red hæmatite and copper-pyrites are found, all much mixed together. These ores were almost certainly originally held in solution, and deposited by hot springs in clefts and fissures, as traces still remain of the former thermal activity.

E. M. D.

FOSSIL RIPPLE-MARKS AND BROWN-COAL MINING IN BAVARIA.

Die fossilen oberoligocänen Wellenfurchen des Peissenbergs und ihre Bedeutung für den dortigen Bergbau. By A. ROTHPLETZ. *Sitzungsberichte der mathematisch-physikalischen Klasse der Königlich Bayerischen Akademie der Wissenschaften zu München*, 1904, *vol. xxxiv., pages* 371-382, *and* 1 *plate*.

For the last decade, some attention has been devoted by the officials of the coal-mining districts of Upper Bavaria, to the question whether the

steeply-inclined, southward-dipping, Upper Oligocene coal-seams of the Peissenberg form a normal sequence or whether they are overthrust; in other words, whether they constitute the northern limb of a syncline which gradually flattens out towards the Ammer, or whether they bend round northward below the surface with (at first) an increasingly steep dip, as the overthrust southern limb of a syncline. An irrefragable answer to this question would be of great importance from the mining point of view, as well as from that of the tectonic geologist.

The district has lately been remapped by the Bavarian geologists, with the result that the conviction has gained ground that the Peissenberg seams (in contradistinction to the views held by the older geologists) do occupy their normal position. The chief workable seams lie below two beds of quartzose sandstone and sand, and but few seams occur between those two beds; now, these conditions are repeated in the Penzberg district, where it is known that the sequence is normal, although the existence of the aforesaid quartzose sands has not yet been actually proved in the intervening area.

The author, however, brings forward evidence, in the shape of ripple-marked sandstones from the Peissenberg mines, which were discovered there in the summer of 1904, to prove that there is no longer any question that the coal-seams are overthrust; for the accompanying sandstone-beds are shown by the ripple-marking, sun-cracks, worm-tracks, etc., to be lying with their original undersides uppermost. This evidence came to him as a great surprise, as he had of late years inclined more and more to the view that the Peissenberg sequence is normal. It seems probable that the lower shaft, if driven far enough, will strike the coal-seams deeper down, dipping more and more steeply, until at last the dip changes from south to north. Along the Peissenberg ridge runs a big fissure-fault, hading southward, which undoubtedly constitutes an important tectonic boundary and probably demarcates the limit of the workable coal-area. L. L. B.

PETROLEUM-BEARING FLYSCH OF THE TEGERNSEE DISTRICT, BAVARIA.

Der Flysch im Tegernseer Gebiet mit spezieller Berücksichtigung des Erdölvorkommens. By WOLFRAM FINK. *Geognostische Jahreshefte 1903* [1905], *vol. xvi., pages* 77-104, *with* 11 *figures in the text and* 1 *map.*

In the Flysch-deposits of this neighbourhood the author recognizes, and describes in some detail, four chief lithological divisions: (1) the sandstones and conglomerates; (2) the siliceous limestones or *kieselkalke*; (3) the marls; and (4) the slates, which occur at several horizons in the group.

Dealing with the western shore of the lake (Tegernsee) he summarizes the history of the oil-deposit there, which, in the Middle Ages and later, was an object of veneration, the so-called "St. Quirinus oil" being then regarded as a miraculous specific for practically every disease with which humanity has ever been afflicted. It was discovered by the monks of the neighbouring abbey between the years 1430 and 1441, and they and their successors drove a thriving trade with the "miraculous oil" for many a generation, until a matter-of-fact nineteenth-century chemist demonstrated that it was neither more nor less than crude petroleum. In 1838, the attempt was made, by means of adits and shafts, to get nearer the actual source of the flow, and thereby to increase the annual output; but this yield

now did not exceed 176 gallons, and in 1840, the overpowering evolution of pit-gases put a stop to further experiments in that direction. However, fresh trial-borings were put down as recently as 1898 and 1899, both on the original site and on the lake-shore. From an analysis made in 1883, it was shown that this oil is very rich in naphtha and paraffin-constituents, and bears comparison with the Pennsylvanian petroleum. Details are given of the borings, and from the summary of results we learn that in no case was oil struck at a depth greater than 328 feet below the surface; and that it occurred exclusively among the strata belonging to the group of the siliceous limestones or *kieselkalke*. The base of the Flysch-deposits as a whole was not reached at a depth of even 1,970 feet.

Turning then to the eastern shore of the lake, the author mentions the occurrence of petroleum-bearing *kieselkalke* at the sources of the Fehnbach; these limestones are dark-grey, slightly micaceous, and on heating give forth smoke profusely, with a strong odour of petroleum. They contain an abundance of foraminifera of early Tertiary age, and immediately below the spot here described is an outcrop of Cretaceous limestones. Several other occurrences of petroleum in the *kieselkalke* of the eastern shore are on record.

A glance at the map shows that, while on the western lake-shore, the Flysch-deposits extend over a considerable area from north to south, and are predominantly sandstones; on the eastern shore they are packed closer together and the *kieselkalke* predominate over the sandstones. A good and conspicuous geological boundary is formed by the red slate, which invariably occurs in the district here described at the junction of the two above-mentioned rocks. The tectonic structure is not that of a regular succession of synclines and anticlines, but the strata appear to have been folded and then packed over each other. Evidence of overthrust is cited from one locality. Faults are numerous, the most important being the Tegernsee main cross-fault which runs from north to south.

The question whether the petroleum is of secondary occurrence in the Flysch, and really originates from the older Haupt Dolomit has been the subject of lengthy debate. The author marshals the evidence in favour of the contrary view, concluding that the Tegernsee petroleum originated in the group of strata wherein it now occurs. He believes, too, that its genesis may be traced to the microfauna, the remains of which are abundant in the Flysch thereabouts, namely, foraminifera, radiolaria, pteropoda, diatomaceæ, etc. L. L. B.

THE PINCHING-OUT, ETC., OF COAL-SEAMS IN THE SAARBRÜCKEN COAL-FIELD, GERMAN LORRAINE.

Einige Beobachtungen an Flötzverdrückungen im Saarkohlenrevier. By Ernst Kohler. *Geognostische Jahreshefte 1903*, [1905], *vol. xvi., pages* 63-68, *with* 5 *figures in the text.*

The author points out that the ordinary usage among mining men of the word *verdrückung*, which *sensu stricto* implies pinching-out, is somewhat lax. It is apparently extended to all the irregularities of which a coal-seam may be capable. Confining it, however, to its true meaning, he holds that such pinching-out is due in some cases to thrust or drag of the seam along a fault-plane or a flexure. He describes and figures instances due to other causes observed by him in the Emil coal-seam, in the Geislautern

and Hostenbach collieries; this seam happens to be regarded as the best that is worked in either of these collieries, and yet in the matter of pinching-out it differs from the generality of the seams of the Lower Flaming Coal Group of the Saare basin, which appear on the whole (apart from faulting or very gradual changes in thickness) to be free from irregularities over a considerable area. In one case, he figures what uncommonly resembles the "wash-outs" familiar to British observers; and states that the space where the discontinuity of the seam arises is filled up with "Red Measures" (marls: red, yellow, and grey, or red-and-yellow mottled). But, in the other case, the "wash-out" is reversed, if one may so express it, and the "Red Measures" bulge up the seam into an interstratal anticline, that is, an anticline which only affects one stratum and not those above or below: the "Red Measures" forming in fact a sort of lenticle (in section) at the floor of the seam. His third figure, a plan showing the course of the "wash-outs" in the Emil seam, supplies the solution: we have here the picture of an ancient stream, flowing from north-east to south-west, the meanderings of which cut again and again across the coal-deposit. This hypothesis is confirmed by the character of the vegetable remains found in the "Red Measures" which fill up the "wash-outs": these remains are in the comminuted condition which results from transport in swift-flowing waters. The well-preserved leaves, etc., found so abundantly in the underlying shales are conspicuous by their absence. As Dr. Passarge has shown, Coal-measure conditions are being reproduced at the present day in the vast area of swamp which forms the delta of the Orinoco and its tributaries, and the lithological and the stratigraphical characters of the Saarbrücken "wash-outs" can be paralleled by examples from the Venezuelan coast-land. Such coal as remains above or below the "wash-out" in the instances described by the author is either like a mixture of soot and earth, or is "petrified" (traversed by nodular or lenticular masses of stone of dolomitic nature). It may be added that, both at Geislautern and at Hostenbach collieries, the occurrence of erect tree-trunks in the Coal-measures is frequently observed. The author conceives that, by means of a systematic mapping of "wash-outs" in a coal-field, it would be possible to reconstruct the ancient river-system of that area, and thus obtain a view of the surface-relief as it existed in Coal-measure times.

L. L. B.

THE GENESIS OF KAOLIN-DEPOSITS IN SAXONY.

Die Weisse-Erden-Zeche St. Andreas bei Aue. By O. STUTZER. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii., pages* 333-337, *with* 2 *figures in the text.*

Most text-books perpetuate the view, held by the older school of geologists, that kaolin is the ultimate product of the weathering of felspar, and that deposits of china-clay are consequently due to extreme weathering of highly felspathic rocks.

Careful observers, however, long ago noted facts which were hardly in accord with this delightfully simple hypothesis. Thus, kaolin-deposits, of quite small horizontal extent but going down to untold depths, were found cropping out on hill-tops; while, on the other hand, deposits of weathered felspathic débris, showing not the slightest trace of kaolinization, were found covering wide stretches of plain and valley.

Mr. H. Rösler has recently pointed out the chief characters which

differentiate mere weathering from kaolinization, and these are summarized by the author of the paper under review in tabular form. Both writers are convinced that kaolin-deposits are the result of the decomposition of highly felspathic rocks by post-volcanic processes, in other words, by the upward percolation of thermal solutions or vapours. Such deposits are classified by Mr. Rösler as primary deposits; the material transported from these to another spot would there form secondary deposits, of greater or less purity according to the distance which the kaolin has travelled from the original site; and this would admit of a subdivision of such secondary deposits into (*a*) kaolin-sandstones, and (*b*) kaolin-clays.

It is claimed that the oldest known and first-worked kaolin-deposit in Europe, that of Aue in Saxony, furnishes ample evidence confirmatory of the "post-volcanic" hypothesis. The deposit was discovered in the year 1700, and, for a century and a half, the famous Meissen porcelain-factory was chiefly supplied with china-clay from Aue. Subsequently big deposits of purer kaolin were discovered at Meissen; and the workings at Aue have for many years passed into the domain of ancient history. The geological conditions of the Aue deposit completely preclude any possibility of its having arisen through weathering. Moreover, undecomposed iron-ores are frequently associated with the kaolin, also nodules of chert, and huge crystals of quartz, with their pyramidal apices invariably directed downwards. The association of iron-ores with kaolinized country-rock, it will be remembered, has also been noted at Broken hill and at the Comstock lode. The day is not far distant when the "post-volcanic" theory will be held to apply to all kaolin-deposits without exception, and then perhaps the text-books will follow suit. L. L. B.

PYRITES-DEPOSITS IN THE SAXON ERZGEBIRGE.

Über einige Kieslagerstätten im sächsischen Erzgebirge. By R. Beck. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii., pages* 12-23, *with* 11 *figures in the text.*

The two now comparatively little known deposits, with which the author first of all deals in this paper, are no longer worked, but he regards a study of them as important, in view of the light which they throw upon the genesis of pyritous ores.

The writer describes the mines formerly worked immediately north-west of the little town of Elterlein. Here, the bed-like ore-body conforms both in strike and dip with all the convolutions of the garnetiferous mica-schists among which it lies: the thickness varies from a minimum of an inch or so to a maximum of 5 feet, but the average variation is between 6 and 11 inches. The ore is predominantly iron-pyrites, but with it are associated marcasite, brown and black zinc-blende, and occasionally copper-pyrites and galena, with a little quartz. The proportion of silver present in the pyrites is generally small, but it rises *pari passu* with a rise in the admixture of blende. The ore is described as "intimately intergrown" with the neighbouring country-rock, which is, moreover, for a distance of 2 feet or so, impregnated with pyrites in a fine state of division. Thin partings of schist often split up the ore-body into two or more layers. Despite its concordance with the bedding of the schists, the ore-body sends out into them several apophyses or ramifications, of the same mineralogical composition and structure as the parent-mass itself. All the known conditions point to

the inference that the deposit is a bedded vein, of a type very unusual in the Erzgebirge, but comparable in many respects with such Norwegian pyrites-formations as those of Röros.

The pyrites-deposits of Johanngeorgenstadt occur in the same region of contact-metamorphosed phyllites, in association with the tourmaline-granite of Eibenstock-Neudeck, as the complex of cassiterite-veins and cobalt-silver-ores. The pyrites-formation occupies a belt about 1¼ miles long, which, with a strike trending round from north-north-east to north-east, ranges west and north-west of the town just mentioned. The ore occurs in numerous narrow bands among the schists, or impregnates them in a state of fine division. It is predominantly iron-pyrites, with which are associated chalcopyrite, zinc-blende, galena, and a little quartz and calcspar. All the metalliferous constituents of the deposit contain a small proportion of silver. In some cases, too, magnetite, fluorspar, cassiterite, etc., occur. A microscopic examination of some specimens got from the Rosina Charitas mine reveals the presence of acicular crystals of anthophyllite among the pyrites, recalling vividly the similar occurrence of anthophyllite in association with the pyrites of Falun in Sweden. It seems tolerably certain that the pyrites-deposits of Johanngeorgenstadt were originated during the process of contact-metamorphism which affected the rocks of that neighbourhood; or, at all events, that they assumed then their present aspect. They therefore are probably of older formation than the complex of cassiterite-veins, etc., above mentioned.

The author then discusses the latest evidence in regard to the sulphidic ore-deposits, which lie between Klingenthal and Graslitz in the Western Erzgebirge, as revealed by the progress of mining operations within the last three years or so. These ore-bodies are of bedded appearance, conforming in dip and strike with the phyllites among which they are intercalated. They are not, however, true beds, but belts or zones of impregnation, as B. von Cotta rightly pointed out more than a generation ago. The district is one of great tectonic disturbance, and the relationships of the Klingenthal ores to the contiguous country-rock are extremely varied. The author describes and figures a section of the metalliferous deposits as exemplified by the No. 6 or Segen-gottes bed. Here the ores appear to be predominantly magnetic pyrites, chalcopyrite, and iron-pyrites, the average thickness of the ore-body being about 5 feet. It is plainly divisible into two portions, an upper and a lower, whereof the former (in which the copper-pyrites predominates) constitutes the most favourable mixture of ores. The brecciated aspect of some portions of the deposit, wherein magnetic pyrites plays the part of the cementing-material, recalls similar phenomena observed in the Sulitjelma mines: the author declines at present to commit himself to any definite explanation of the origin of this breccia.

In contradistinction to Mr. C. Gäbert's experience, he failed to discern the presence of any trace of tourmaline in the deposits which he examined; and he suggests that the abundance of tourmaline, mentioned by Mr. Gäbert as pointing to the genetic connection of the ore-bodies with the eruption of the neighbouring granite, may be a very local phenomenon.

The author strongly recommends other investigators to study these deposits of the Klingenthal district, as such a study may ultimately lead to the settlement of the much-debated question of the genesis of sulphidic ores of the Röros and Rammelsberg types. L. L. B.

TIN-ORE DEPOSITS OF THE ERZGEBIRGE, SAXONY.

Zur Kenntniss erzgebirgischer Zinnerzlagerstätten. By O. MANN. *Abhandlungen der naturwissenschaftlichen Gesellschaft 'Isis' in Dresden,* 1904, *part ii., pages* 61-73, *with* 2 *figures in the text.*

This, the first of what is apparently to be a series of memoirs, deals with the stanniferous deposits of Gottesberg and Brunndöbra, near Klingenthal. A few of the widespread ancient workings, abandoned for many generations, have been lately made accessible again, and thus a scientific investigation of the deposits has become possible. They are evidently associated with the contact-metamorphic zone which marks the junction of the intrusive, coarsely-crystalline tourmaline-granites with the older phyllites, quartz-schists and hornblende-schists.

In the Gottesberg district, the ore-occurrences consist partly of small crystals of cassiterite impregnating grey quartz, and partly of tin-ore in a microscopically fine state of division, associated with fairly large grains and nodules of pyrites and arsenical pyrites. In following up a deposit of the latter kind, it is found that the sulphidic ores gradually assume the predominance, to the ultimately complete exclusion of the tinstone. Most of the minerals that one is accustomed to associate with stanniferous deposits, such as topaz, fluorspar, molybdenite, etc., are here conspicuous by their absence. Veins of chert, bearing red hæmatite, are associated with the tinstone-bearing veins, or are seen to cut across them.

In the Brunndöbra district especially do the veins occur in the contact-metamorphosed slates: the pitch is generally steep, and the strike all but universally northerly or north-westerly. The main mass of the veins consists of quartz and tourmaline, the latter exhibiting certain crystallographic characters which are reminiscent of the analogous mineral from the Mount-Bischoff tin-ore deposits in Tasmania. The tinstone seems to be concentrated by preference in those parts of the veins which are richest in tourmaline. Under the microscope the cassiterite-crystals are remarkable for their concentric zonal structure, as many as ten light and dark bands alternating in some cases. Needles of tourmaline are seen to pierce them, and in some instances the cassiterite presents the appearance of having been "gutted," so to say, and then "restuffed" with tourmaline; but in no case is a cassiterite-crystal embedded or included in the tourmaline. Irregular masses of red hæmatite are of common occurrence in the gangue. The hæmatite-veins proper, of later date than the cassiterite-veins, repeatedly cut across the latter. The stanniferous veins, being only from 4 to 12 inches thick, would hardly have given rise to mining operations of any considerable extent, had it not been for the "impregnation-zone" extending on either side for about 20 inches into the metamorphosed country-rock. In some cases, the area of impregnation was immensely extended. It is often very difficult to determine exactly where the vein ends and the country-rock begins. The stanniferous veins are supposed to have been formed at a time when the granite-intrusion had already begun to solidify superficially, and simultaneously with the silicification of the neighbouring rocks. They are not, as at Mount Bischoff in Tasmania, genetically associated with the advent of the topaz (which was a later comer than the cassiterite at Brunndöbra); while on the other hand, those Tasmanian tin-ores do not actually occur in tourmaline-rock as do these Saxon ores. In outward appearance, the close resemblance between the Mount-Bischoff and the Erzgebirge deposits is very remarkable.

The author's final observation, that nature travels by many roads to reach the same goal, is one of those truths which are not so universally borne in mind as they should be. L. L. B.

SILVER-BISMUTH ORES OF THE JOHANNGEORGENSTADT DISTRICT, SAXONY.

Die Silber-Wismutgänge von Johanngeorgenstadt im Erzgebirge. By W. VIEBIG. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii., pages* 89-115, *with* 6 *figures in the text.*

The bismuth-mines of Johanngeorgenstadt form a cheerful contrast to the decadence which has of late years overtaken the erstwhile flourishing metalliferous mining-industry of the Erzgebirge. Not only does the present price of bismuth warrant the hope that the activity now reigning in the above-mentioned mines may be long continued, but the occurrence therein of uranium-pitchblende of high radio-activity is an additional factor of considerable importance.

The little mining town of Johanngeorgenstadt lies close to the Bohemian frontier, on the railway from Chemnitz to Karlsbad, 2,470 feet above sea-level, in a country where the rivers have cut deep trenches in the northern slopes of the Erzgebirge. Here and there an isolated mountain, such as the Grosse Plattenberg, rises high above the general level of the hills. The phyllites, among which the metalliferous veins occur, appear to fill up the flat basin which intervenes between the great granite-mass of the Eibenstock and the granitic laccolith of the Grosse Plattenberg. These phyllites strike generally south-east and north-west, and dip from 10 to 25 degrees north-eastward; they have evidently undergone contact-metamorphism, to an extent which varies with their proximity to the respective granite-masses. The general picture is complicated by the occurrence of fault-fissures of later age, infilled with ores of the iron-and-manganese group, which have disturbed the original stratigraphical relationships. The phyllites are described, and apart from the normal facies of quartz-phyllites and albite-phyllites, are classed in three categories corresponding to the principal zones of contact-metamorphism. As in so many other localities in the Upper Erzgebirge, ore-deposits consisting predominantly of pyrites are intercalated with apparent conformity among the phyllites, as many as ten such beds having been counted in a vertical thickness of 230 feet of rock. These deposits were at one time the object of active mining operations, but their thickness was extremely variable. The argentiferous veins which traverse them were worked successfully for silver, and lately rich masses of bismuth-ore have been struck in one of these veins. At another place, good finds of uranium-pitchblende have been made along the intersection of such a vein with the pyrites-bed, but the vein ceases to be ore-bearing 7 feet or so below that bed and 1 foot above it.

The drift-deposits of the district, chiefly made up of rolled detritus of granite, basalt, slates, and vein-quartz, were formerly washed for tinstone along the valley-courses, and seem to have yielded a fair quantity of that ore. The author gives a detailed description of the eruptive rocks of the area: tourmaline-granites, kersantite-dykes, nepheline-basalts, and then proceeds to deal with the metalliferous reefs or veins, which he groups as follows: (*a*) The older system, including the tin-ore veins and the pyrites-blende-galena-veins; (*b*) the younger system, including the cobalt-and-silver-

ores and the iron-and-manganese-ores. Those of group (a) are no longer worked; and mining operations have been suspended but recently on the ferromanganiferous veins. It is quite another story in regard to the silver-bismuth veins, which belong to the cobalt-silver-ore formation: they are, perhaps, the most important deposits in the district, in view of their widespread occurrence and their industrial value. The greater number of them range through the Fastenberg and the neighbouring hills, west of Johanngeorgenstadt, no less than 217 being counted (in an area 9,840 feet long and 6,555 feet broad) according to one writer, and over 1,500 according to another, who compares the complex to a gigantic stockwork. A narrow belt of veins, important for the bismuth-miner, extends in the opposite direction, eastward into Bohemia. Most of them strike north-west (though east-north-easterly and easterly strikes are also observed), and are characterized by a steep dip. The thickness is variable in the extreme, even within the same vein, and nips-out are common rather than otherwise; but the average may be reckoned as ranging between 4 and 8 inches, although maxima of 20 inches and more are frequently noted. The principal gangue-mineral is a dirty-grey, fine-grained crystalline quartz, dolomite coming next in importance. Calcspar and fluorspar are of rare occurrence. The ores were long worked for silver in the olden days, but the activity of the miner is now directed to the bismuth-ores: these include "native bismuth" (much intergrown with quartz and other minerals), containing from 18 to 34·2 per cent. of the pure metal; "bismuth-ochre" (oxide, hydrated oxide, and hydrated carbonate of bismuth), a grey to greyish-yellow, "earthy" and cryptocrystalline mineral, probably derived from the decomposition of the "native bismuth"; and, far more rarely, sulphides and silicates of bismuth.

The uranium-pitchblende of Johanngeorgenstadt, which is associated with the bismuth-occurrences, exceeds in radio-activity the similar ores of Joachimsthal, Příbram and Cornwall. It occurs, too, in comparatively large quantity: and formerly-abandoned workings are now being re-opened, in consequence of the demand for radium-minerals. Cobalt- and nickel-ores play a very modest part in this district; nor is much industrial importance attributed to the galena, zinc-blende, and iron-pyrites which widely impregnate the bismuth-ore formation. On the other hand, what may perhaps be properly termed "gossans" of red and brown hæmatite are of conspicuous occurrence. It is remarked, by the way, that the old rule that vein-crossings or intersections are favourable to enrichment hardly ever applies in the case of the Johanngeorgenstadt silver-bismuth ores. As to the genesis of these ores, they probably were precipitated from thermal waters which, during the moribund phase of the granitic eruptions, percolated upwards through the fissures in the rocks: the very latest phase of all being represented by the hot mineral springs of Karlsbad, Marienbad, etc., in Northern Bohemia.

On the whole, mining operations are still conducted on rather a primitive system in the Johanngeorgenstadt district, partly because of want of co-operation among the small mine-owners. From the statistics set forth in full detail by the author, it appears that, in 1903, the output of bismuth-ore from the five Saxon mines at work amounted to 56,543 tons, an unprecedented quantity. In 1896, the market-price of bismuth had reached low-water mark: since then it has risen almost continuously. Statistics are also tabulated of yearly outputs and values (since 1886) of uranium-pitchblende. L. L. B.

CINNABAR-DEPOSIT OF VALLALTA-SAGRON (AUSTRO-ITALIAN BORDERLAND).

Die Zinnoberlagerstätte von Vallalta-Sagron. By A. Rzehak. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii.*, *pages* 325-330.

This ore-deposit occurs partly within Italian territory (province of Belluno), and partly within Austrian (the Primiere district of Tyrol), a circumstance which has rather hindered than helped its industrial development. The cinnabar-bearing rocks are found on both banks of the torrential Pezzea, which flows down from the northern flank of the Sasso Largo; the valley lies high up (6,500 feet above sea-level or more) among the magnificently picturesque dolomite-mountains, and is accessible only by a bridle-track. The stratigraphical conditions, on a nearer survey, do not appear quite so simple as they have been postulated in Prof. E. von Mojsísovics's maps and memoirs. Moreover, rocks, classified by the older authors as sandstones and porphyries, appear to be rather of the nature of crush-breccias, crush-conglomerates, and altered porphyritic tuffs. The last-named are the cinnabar-bearing rocks proper; they contain many fragments of talco-phyllitic and porphyry-débris, and are generally greenish-grey, rarely pink in colour. The author enters into some detail regarding the association of gypsum (in nests and veins) and graphite-schists with the deposit. In the old workings, the greatest wealth of ore appeared to be concentrated in the neighbourhood of the black (graphitic) schists, and it is said that much of it was comparable in character with that of Idria. The talco-porphyritic gypsiferous rocks contain the cinnabar mostly in the form of bright-red granules, but occasionally also in the form of thin veins. Native mercury has been so far very rarely recorded here.

The author observes that, "like almost all mercury-ore deposits," the Vallalta occurrence is a typical impregnation, originating from the upward percolation, through fissures no longer discernible, of thermal waters charged with metalliferous particles. The scarcity of pyrites, usually an abundant associate of mercury-ore deposits, is noticeable. He says that, any attempt to give a graphic description of the Vallalta-Sagron deposit, can only set forth the extraordinary complexity of the stratigraphical conditions, but must inevitably fail to give a clear idea thereof. Wherefore, he has refrained from adorning his paper with illustrations or diagrams. So too, it is venturesome to forecast the industrial future of the deposit: undoubtedly untouched ores are still in existence, but then the formerly-worked portions have not been really exhausted, and an enrichment in depth may be looked for in some places with confidence. The local supply of timber, water and labour, is abundant and easily available, and the construction of the long projected road through the Miss valley will bring the workings within 14 miles of the railway. L. L. B.

ARGENTIFEROUS LEAD-ORES OF ROSSETO, ELBA.

Neue Untersuchungen B. Lottis auf Elba: silberhaltige Bleierze bei Rosseto. By K. Ermisch. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii.*, *pages* 141-145, *with a section in the text.*

This paper is based on the communication made by Dr. B. Lotti to the *Rassegna Mineraria*, concerning the discovery of silver-bearing lead-ores in the deep-lying zone of the brown hæmatite-deposit of Rosseto, near Rio, on

the eastern coast of the island. The genetic relationship between the oxidic iron-ores and the sulphidic ore-deposits of Elba and the neighbouring districts of the mainland (Campiglia, Massa Marittima, and La Tolfa) may now be regarded as established beyond question: they are all of Miocene age, and all derived (more or less directly) from the eruptions of acidic rocks which took place during that period.

At the extreme northern end of the Rosseto deposit, the progress of the opencast workings revealed the presence of irregular masses of galena, embedded in a ferruginous mass with which are commingled magnetite, carbonate and sulphate of lead in a concretionary form, and traces of sulphur. This is close to the point where the iron-ore passes into the cavernous Rhaetic limestone, both the latter and the hæmatite overlying almost horizontally the quartzose Permian slates (Verrucano), and passing westward beneath the Upper Liassic *Posidonia*-shales. There appears to be no doubt that the hæmatite has in part metasomatically replaced the cavernous Rhaetic limestone: the iron-ore ceases at the point where the lead-ore appears; while the limestone within a short distance suddenly assumes a steep dip, and then, as before mentioned, passes beneath the Upper Lias. This in turn is overlain by Eocene marls and slates, among which are intercalated eruptive diabases and cherty and jaspery bands of rock. Analysis shows the percentage of lead in the galena to amount to 74·4, while that in the carbonate ranges from 66·4 to 69·4: the average percentage for all the lead-ores is stated as 69·75, and the average yield of silver is no less than 89·56 ounces per ton. The highly ferruginous samples of lead-carbonate are extremely rich in silver, and are so deceptively like the ordinary brown hæmatite in appearance, that one is led to suspect that there may be considerable masses of such lead-ore present in this deposit which have not as yet been identified. Meanwhile, mining operations in this particular portion of the workings are suspended, until such time as the concessionaires have reached an agreement with the Italian Treasury; for that Government department reserves to itself all rights over metalliferous ores other than those of iron.

It seems quite possible that the plumbiferous deposit will be found to extend in depth along the junction between the Rhaetic limestone and the underlying Permian, constituting, so to say, the "root" of the more superficial hæmatite-deposit: the latter being, in that case, a mere gossan. Parallel instances might be cited from the Pyrenees, where the progress of mining operations, at first directed to the oxidic and carbonated ores of iron near the outcrop, has revealed the presence in depth not only of sulphides of iron, but also of other sulphidic ores, more especially galena.

L. L. B.

SALT-MINES OF RUMANIA.

Das Salzvorkommen in Rümänien. By W. Teisseyre *and* L. Mrazec. *Österreichische Zeitschrift für Berg- und Hüttenwesen,* 1903, *vol. li., pages* 197-202, 217-220, 231-234, *and* 247-251, *with* 16 *illustrations in the text and* 1 *geological map.*

The vast salt-beds of Rumania lie on the southern slopes of the Carpathian mountains. They occur in connection with the Flysch (Vienna sandstone), which gradually gives place to a crystalline formation. This sandstone, the course of which is strongly marked, especially at the western

curve of the mountains, lies above the great belt of saliferous clays running north and west of Wallachia and Moldavia. In some places, it is overlain by later Tertiary deposits. The nummulites found in it characterize it as belonging to the Eocene and Lower Oligocene ages. Ammonites occur in the Cretaceous floor of the Flysch. Many of the salt-formations, however, date from the Palæozoic era, masses of rock-salt, hundreds of feet thick, being often found, which certainly belong to this earlier geological period. These are often thrust up over the later Miocene beds of saliferous clay, and the two strata are sometimes hardly distinguishable. Practically all these masses of Palæozoic salt, and the springs which issue from them, form parts of great anticlinal folds. The layers of marl, sandstone and gypsum, with which they are interspersed, being more plastic than the salt, the latter has forced its way through them, producing these anticlines with such regularity that, in default of other indications, the presence of salt may in Rumania be almost inferred from the lie of the strata. It is only where the thill of the salt-mass has been laid bare by erosion, that its original synclinal formation can be traced. The whole sub-Carpathian district bears evidence of much disturbance, and the shore-line must have varied continually.

The belt of Miocene saliferous clays attains a maximum width of 21¼ miles, and resembles the salt-beds of the Northern Carpathians. It rests on conglomerate, consisting chiefly of granite, crystalline rocks and quartzite, above which marl and sandstone predominate in the red and grey clays. Tuff (*palla*) and *Globigerina*-marl are also frequent. The clays lie in a great synclinal fold, corresponding to a depression, which runs almost through the Southern Carpathians, and is bounded on either side by faults. Sometimes the salt-strata are much folded, wedged between the Vienna sandstone and the Sarmatian rocks, and are connected to the sub-Carpathian Pliocene zone.

A large Miocene salt-deposit occurs at the town of Slanik, where an enormous fold or bay seems to have been originally formed, in which the salt settled. There are many other districts, scattered along the southern slopes of the mountains, where salt has collected in greater or smaller quantities. Sometimes *Globigerina*-marl forms the bulk of the saliferous clay, sometimes it is quite devoid of fossils; and these beds seem to have been deposited in rather deeper water than the Palæozoic.

The salt occurs chiefly in enormous lenticular masses, so vast that their extent is only imperfectly known. One of these alone is supposed to be about 1¾ miles long, 328 feet thick, and at least 1,650 feet wide. Another has been estimated to contain 264,000,000 tons of rock-salt, of which not 10,000 tons had, up to 1900, been excavated. There are fifty known deposits of rock-salt, but only four are at present worked, salt being a monopoly of the Rumanian Government.

Amber and rock-oil are occasionally found, and carburetted hydrogen is irregularly distributed through the salt.

A singular feature in the geological history of the district is the grouping together of salt-formations of different geological ages. Thus the principal salt-beds both of the Palæozoic and Miocene eras lie together along the south-eastern slope of the Carpathians, and salt also occurs in the later Tertiary. Originally the Mediterranean-Podolian sea must have stretched over the region now bounded by the Carpathians. The geological characteristics somewhat resemble those of the Dead sea, consisting of a fold, and of a deep depression formed by fissures.

Throughout the district there are many springs of saturated brine, and occasionally small mud-volcanos. These are probably derived from pockets of salt, and not from the saliferous clay. In the vicinity are masses of fossil-bearing and oil-bearing conglomerate, into which huge blocks of salt appear to have been accidentally forced. Salt is also found in abundance in the Pliocene strata, in the axes of the synclines: in the centre of these the springs are salt, while those at the edges are sweet. There are twelve lakes aad swamps, the waters of which are impregnated with salt, sulphate of soda and sulphate of magnesia. They appear to have no connection with the saliferous clays. The springs, throughout the country, are often salt, and seem to point to a time when there were large salt-water lakes. E. M. D.

BECKELITE, A RUSSIAN MINERAL CONTAINING RARE EARTHS.

Ueber Beckelith, ein Cero-Lanthano-Didymo-Silikat von Calcium. By J. MOROZEWICZ. *Bulletin International de l'Académie des Sciences de Cracovie,* 1904, *pages* 485-492 *and* 1 *plate.*

In one of the numerous apophyses of a mass of elæolite-syenite, which forms one of the constituents of the granitic plateau of the Azov region, and was described by the author as mariupolite (a new rock-variety) in 1902, he has recently discovered a wax-yellow mineral showing conchoidal fracture, as also a lustre and refractive power far exceeding those of the pyrochlore from the Urals. Carefully conducted chemical analysis proves that, in composition, this mineral corresponds to the formula $Ca_3(YCeLaDi)_4(SiZn)_3O_{15}$, or, if only the most important constituents be considered, $Ca_3(CeLaDi)_4Si_3O_{15}$; therefore, it may be termed a cero-lanthano-didymo-silicate of lime. The author proposes for it the appellation beckelite, in honour of Prof. Friedrich Becke, of Vienna. The mineral has a hardness of 5 in the Mohs scale, its specific gravity is 4·15, it is easily soluble in acids but is infusible in the blowpipe-flame, it crystallizes in the tetragonal system, and exhibits distinct cleavage. L. L. B.

BROWN IRON-ORE AT KISEL IN THE URAL DISTRICT.

Über die Brauneisensteinlagerstätten des Bergreviers von Kisel im Ural (Kreis Solikamsk des Permschen Gouvernements). By L. MRAZEC *and* L. DUPARC. *Österreichische Zeitschrift für Berg- und Hüttenwesen,* 1903, *vol. li., pages* 711-715 *and* 735-740, *with* 10 *illustrations in the text.*

The ore-deposits stretch from the hilly district at the foot of the Ural mountains to the town of Kisel, where the ores are smelted. The strata comprize Devonian, Carboniferous and Permo-Carboniferous. The most important tectonic features affecting the coal-seams and ore-deposits are a Carboniferous anticline passing into two smaller saddles, and containing rich seams of coal, and a syncline to the east, containing a limestone rich in *Fusulina.* Beyond this fold is a Devonian anticline, and between it and the easterly saddle is a syncline, known as the Artemiewka, where most of the brown iron-ore is found.

The ore-deposit follows the Artemiewka syncline for about 7½ miles. There are three kinds of brown iron-ore, heavy, light and cellular. The first is tough, crystalline, and occasionally contains iron-pyrites; it is more

abundant and valuable than the others. The light ore is earthy, and is found embedded in the heavier, while small quantities of cellular iron are scattered throughout the deposit. The ores contain from 51 to 52 per cent. of iron, 0·12 per cent. of sulphur, and 9 to 10 per cent. of silica. The deposit varies in thickness from 3 to 85 feet, and is divided into two parts: the southern alone is worth working.

Mining dates from 1786, when the ore was dug, partly from open workings, partly from a shaft with adits and galleries. The quantity of ore raised up to now is about 1,600,000 tons, and about 2,500,000 tons is still unworked.

Brown iron-ore, when found with clay and chalk, is supposed to be an alluvial deposit, but this depends on local conditions. The most probable theory is that the deposit was derived from surface-water strongly impregnated with iron. Iron is very generally diffused throughout the Eastern sub-Uralian district, and there are also strata of ferruginous clay containing from 23 to 28 per cent. of iron.

The Devonian anticline contains an oolitic ore interposed between the fossiliferous coral limestone and the Middle Devonian quartz-sandstone, and sometimes gives place to ochreous clay and hæmatite. It is probably of sedimentary origin, deposited along a coast-line in fresh water, like the hæmatites of the United States. Bog iron-ore, rich in fossils, and forming a bed, 3 feet thick, is also frequently found in the district. E. M. D.

IRON-ORES OF THE MAGNÍTNAYA GORA, SOUTHERN URALS.

Die Eisenerzlagerstätten des Magnetberges im südlichen Ural und ihre Genesis. By J. Morozewicz. *Tschermak's Mineralogische und Petrographische Mittheilungen*, 1904, *new series, vol. xxiii., pages* 113-152, 225-262, *with* 4 *figures in the text and* 3 *plates.*

The Magnet hill or Magnítnaya Gora, rather more than 2,100 feet above sea-level, occupies the highest ground in the district, which consists of table-topped rocky hills, with flat valleys in between, dying away eastward into the rolling steppes and merging westward into the great spurs of the Ural range. It lies in the midst of a broad belt of porphyries and felsites, bounded on the north by granites and syenites, and ringed in on the south by porphyrites, diorites, diabases, and tuffs.

The first section of the memoir is taken up by an elaborate description of the petrographical characters of the ore-bearing and contiguous rocks and their decomposition-products, together with a great number of chemical analyses. The rocks are considered in the following order:—(1) Granite-magma, including augite-granite, horneblende-granite, quartz-keratophyre, augitic quartz-porphyry, and felsite; (2) diorite-magma, including augite-diorite (with the decomposed fine-grained variety of which the iron-ores are most intimately associated), diorite *sensu stricto*, quartz-diorite, and augite-labradorite-porphyrite; (3) syenite-trachyte-magma, including ægirine-syenite, augite-orthoclase-porphyry, fine-grained augite-syenite, sillimanite-cordierité-vitro-orthophyre (for which the name atatschite is proposed, after Atátsch, one of the summits of Magnet hill), keratophyre, and trachytoid orthophyre; (4) diabase-magma, including olivine-diabase, diabase-porphyrite, and melaphyre; and (5) crystalline rocks of secondary origin, including the garnet-rock and the closely-associated deposits of magnetite and martite. Of the two ores the former is by far the most abundant, and is very tough

and of compact texture. The magnetic masses contain geodes, occasionally encrusted with crystals of the ore, but the crystals are best developed in the more crumbly masses. In the weathered garnet-rock "pockets" are sometimes found, filled with pure magnetite-sand. At several points the magnetite is seen passing into martite: in illustration of this gradual passage the author appends three chemical analyses, yielding the following percentages of magnetite and martite respectively:—45 and 37, 36 and 48, 22 and 60. Specular iron-ore and red hæmatites also occur, some specimens of the latter containing as much as 98 per cent. of pure ore; and, finally, there are black veins in the weathered garnet-rock which are found to consist of limonite (80 per cent.), pyrolusite (10 per cent.), and clayey residue (10 per cent.). A short description of the sedimentary formations (limestones and thick alluvial deposits) concludes this section of the memoir.

The author deals next with the tectonics and the general lie of the ore-bearing and contiguous rocks. The main mass of Magnet hill (the Berésovaya Gora or Birches hill) consists of granites and diorites which pass one into the other by the intermediary of granitic diorite. The augite-diorite is seamed by veins of fine-grained syenite and orthoclase-porphyry. Veins of quartz-keratophyre and atatschite, the former being probably of earlier origin than the latter, also occur. From the detailed evidence studied by him, the author sketches the following picture of the chronological succession of geological events within this area. At the end of the Devonian and the beginning of the Carboniferous period, Magnet hill was a rocky ridge, washed by the waves of a sea wherein swarmed an abundance of brachiopods, corals, and foraminifera. Then began an epoch of violent dislocation, followed by the eruption of the trachytoid orthophyres, etc., and subsequently of the diabase-magma. The sequence of eruptions was such that, on the whole, the magmas of least specific gravity were erupted earlier than those of higher specific gravity. This period of eruptivity, which was evidently characterized by a certain amount of regularity, having come to an end, there followed a long interval of quiescence, during which the external agencies of destruction and erosion held full sway.

One of the most salient characteristics of the ore-deposits of Magnet hill is that no single one of them rests upon, or is in immediate contact with, fresh, unweathered crystalline rocks of primary origin. There invariably intervenes between such rocks and the ore-deposit a passage-belt made up of rocks of secondary origin, the most conspicuous among these being the garnet-rock, which itself is largely decomposed and epidotized. It is noted that but little ore occurs at those points where there are considerable masses of fresh garnet-rock.

Another noteworthy fact is that all the ore-deposits lie, either upon the flanks of the hills, or at the foot of them. A picturesque description is given of the Belorezk Iron Company's opencast workings at the Dálnaya hill, where the black patches and bands of ore are seen irregularly splashed over the yellowish-brown masses of weathered garnet-epidote-rock, or intermixed with white patches and bands of kaolin: here the black coloration which marks the ore predominates at the lower levels, that is, near the base of the hill, while at the higher levels the yellowish-brown coloration of the barren country-rock predominates. And the testimony of the eye is confirmed by closer investigation and actual measurement of the deposits. Taking into consideration all the available data, as also the results obtained from borings put down to a maximum depth of 262 feet, it may be stated of the

ore-deposits of Magnet hill, in addition to the characteristics above-mentioned:—(1) That they lie among decomposed garnet-epidote and kaolin-rocks, which overlie much weathered augite-felspar rocks; (2) that the higher the stage of decomposition that is attained by the garnet-rocks, the richer are the ore-deposits; (3) that down to a depth of 260 feet or more there is no change of any consequence in the geological conditions of the deposits, but between 45 and 65 feet down impregnations of pyrite begin to appear, represented by gypsum nearer the surface.

The author discusses at great length the conflicting views which have been expressed by various investigators, during the last three-quarters of a century, in regard to the origin of the magnetic iron-ore deposits of the Ural region. He adduces in detail the data which show that the Magnítnaya deposits, unlike those of Blagodat and Vissókaya, are best explained on Dr. Bischof's hydrochemical theory. Augite on the one hand, and quartz and calcite on the other, represent the initial and terminal stages of a series of hydrochemical processes, which eventuate, under certain circumstances, in the separation and accumulation of great quantities of free oxides of iron through the intermediary of garnet and epidote. In conclusion, an elaborate estimate of the amount of ore available at Magnet hill puts it at 9½ million cubic metres (which the author is made in one line to put as equivalent to 37,625,000 tons, and in the next line as equivalent to about a tenth of that amount). The former equivalence is probably the correct one.

L. L. B.

NIZHNI-TAGILSK PLATINUM-DEPOSITS, RUSSIA.

Einige Beobachtungen in den Platinwäschereien von Nischnji Tagil. *By* R. SPRING. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii.*, *pages* 49-54, *with a map in the text.*

These deposits are situated both on the eastern and the western flanks of the Ural mountains, about 22 miles due south of the village of Nizhni Tagil, at the foot of the Solovieva and Bielaya hills. The central massif in this region consists of olivine-rock and serpentine, everywhere margined by pyroxenite. On the west the last-named rock is succeeded by chlorite and talc-schists, the outcrops of which are largely concealed by marshy ground and alluvial deposits. East of the serpentine-massif, and forming the highest summit of the Bielaya Gora (or White mountain) comes a saussuritized quartz-diorite. The olivine-rock is weathered down to a considerable depth, in spheroidal blocks of various dimensions which scale off concentrically; and viewed from a distance, a section of this rock is deceptively similar to a spheroidally-weathering diabase. The fresh, blackish-green, compact kernal of a spheroid, if sliced and examined under the microscope, proves to be a coarse-grained aggregate of olivine, set in a meshwork of chrysotile. Chromite occurs occasionally well crystallized, and sometimes in the form of "strings." The marginal blackish-green pyroxenite weathers much less easily than the olivine-rock, and is quite fresh, even at the outcrop. It is a very tough, heavy rock, consisting chiefly of irregular grains of augite, with some magnetite and green spinel. The passage of the olivine-rock into the diorite is mirrored in the great contrast between the scanty vegetation characteristic of the former, and the luxuriant forest and undergrowth which clothe the latter.

There seems reason to believe that the olivine-rock represents the outcome

of an eruption which took place after the consolidation of the diorite. The occurrence of the platinum is beyond doubt intimately connected with the olivine-rock, and a glance at the map shows that the richest placers occur predominantly along those streams which flow through the olivine-rock area near to the junction with the pyroxenite. Other streams, which flow through either rock singly, are not characterized by placers sufficiently rich to repay working. Another noticeable circumstance is that the most typical and richest of the platinum-placers contain neither gold nor quartz, while in the poorer placers (farther away from the olivine-rock-massif) both gold and quartz are associated with the much dwarfed platinum-grains.

By means of shafts from 33 to 50 feet deep, on the Bielogorskyi Priisk, the alluvia of an ancient river-bed of the Martyan are brought to bank and washed, and are said to yield the highest output in the district: here the bed-rock again consists of olivine-rock and pyroxenite. The author points out that, contrary to certain preconceived opinions, an associated concentration of chromite is by no means an essential condition of the occurrence of platinum in these deposits; further, that an intergrowth of the precious metal with unweathered olivine-rock or serpentine has not been observed. Such occurrences of this kind as have been previously reported are really applicable to weathered olivine-rock, partly associated with intergrowths of chromite.

He does not, however, deny the possibility of the existence of payable quantities of platinum in the fresh, unweathered rock; but the very toughness of the rock would make the working of it extremely costly. It is true, that, given a sufficient water-supply, the weathered crust at least might be dealt with by hydraulicking; but the extremely fine state of division of the platinum in the matrix would probably involve greater loss in tailings than is the case with gold, for example.

The author holds that those writers who claim gabbro, olivine-gabbro, and similar felspathic rocks as additional "mother-rocks" or matrices of platinum, have not looked sufficiently closely into the facts, so far as the Urals are concerned, at least. In that region, platinum-placers, in the true sense of the word, can only be proved to exist in the neighbourhood of peridotites (olivine-rocks).

The waste-heaps from the old placers have been washed five or six times over by the *starateli* or small lessees; and the fact that platinum has still been found in them has led to various wildly imaginative legends, in regard to a possible ever-recurring natural renewal or enrichment. The plain truth of the matter is that the enormous rise in the price of platinum of late years has made the re-washing pay.

In view of the fact that a detailed survey of the Ural region may be regarded as still in its infancy, there is considerable probability that rich platinum-placers, so far untouched, may yet be discovered.

L. L. B.

JURASSIC COAL OF SPITSBERGEN.

The Jurassic Coal of Spitzbergen. By JOHN J. STEVENSON. *Annals of the New York Academy of Sciences*, 1905, *vol. xvi.*, *pages* 82-95.

Although rocks of undoubtedly Carboniferous age exist in the Spitsbergen archipelago, it cannot be said that any workable coal-seam has so far been discovered among them.

In 1882, however, Prof. Nathorst collected a number of plants on the east side of Advent bay, associated with the coal-bearing strata exposed there; and, describing them 15 years later, he determined their age as Upper Jurassic. During the last decade some spasmodic attempts at mining were made, but it was not until the year 1903 that the whole region was thoroughly explored under the auspices of an Anglo-Norwegian syndicate, and in 1904 systematic development was begun on the eastern coast of the bay. The adit, opened about 330 feet above sea-level, shows the following section:—

	Ft.	Ins.	Ft.	Ins.		Ft.	Ins.	Ft.	Ins.
1 COAL	0	4			6 Clay	2 to 0	4		
2 Parting... ...	0	0			7 COAL	1	7		
3 COAL	0	5			8 Rock, sandy ...	3 to 0	5		
4 Parting... ...	0	0			9 COAL	1	0		
5 COAL	0	11						5	0

The author remarks that the foregoing measurements are exact only for the place at which they were made, and the first to fifth coal-seams (inclusive) average not more than 15 inches in thickness. All the seams are worked, but the coal is not of the same character throughout. The coal above the eighth seam or top coal is hard, greyish-black, with a more or less conchoidal fracture, and much like splint-coal. The bottom coal or ninth seam is black, lustrous, tender, exhibiting a prismatic structure. Analyses have been made, with the following results:—

	Top Coal.	Bottom Coal.
Hygroscopic water	3·310	4·696
Volatile matter	19·790	28·560
Fixed carbon	62·763	57·171
Sulphur	0·467	0·413
Ash	13·670 (grey)	9·160 (light brown)
Totals ...	100·000	100·000

Both varieties yield gases burning with a luminous but feebly smoky flame, and neither of them shows the slightest tendency to form a coherent coke. The author comments at some length on the difference in the ratio of fixed carbon to volatile matter observable in these two coals, a difference which far exceeds that often observed as between coals of upper and lower benches. He concludes that the cause of the difference must be sought in conditions existing during the accumulation of the coaly substance, chief among which must be the length of the exposure to such influences as bring about continued combination of carbon and hydrogen, these subsequently passing off in the form of marsh-gas. The roof is a black slate, but as it remains frozen throughout, none of it has been brought down. There are difficulties in the way of securing a complete section of the rocks from the cliff-face, which is a precipitous bluff, 1,600 feet high; but on the whole, the succession may be described as a series of brown, grey, reddish, and yellow flaggy sandstones and sandy shales, with "apparently some streaks of black shale." The succession is evidently conformable, but faults are not infrequent. Another outcrop of coal, at present inaccessible, is seen at a level of 1,300 feet above the sea. The coal-belt has been traced for 10 miles along Icefjord and Sassen bay; and the mineral is worked in a ravine

coming almost down to the anchorage on the west side of Advent bay. If the attempt to mine the Spitsbergen coal on an industrially important scale proves successful, an ample market for it will be found in the North of Norway, where it can be placed at a lower cost than imported British coal.

L. L. B.

MINERAL INDUSTRIES OF THE ASTURIAS, SPAIN.

L'Industrie Minière et Métallurgique dans les Asturies. By P. NICOU *and* C. SCHLUMBERGER. *Annales des Mines,* 1905, *series* 10, *vol. vii., pages* 203-257, *with* 4 *figures in the text and* 2 *plates.*

This memoir embodies the information gathered by the authors, both of them engineers of the French Department of Mines, in the course of a journey to Spain in the summer of 1904. They have supplemented their own observations with particulars and statistics gleaned from official and other documents, both published and unpublished.

From the administrative point of view, the Asturias constitute the province of Oviedo, occupying a belt some 37 miles broad and 155 miles long on the northern slope of the Cantabrian mountain-range. Within this belt, three regions are distinguished: (1) the coastal region, lying between the Bay of Biscay and the first spurs of the Cantabrian mountains; (2) the so-called Cordilleran plateau; and (3) the mountain-and-forest region. The climate is mild and humid, and the character of the labouring classes seems to be influenced thereby, the melancholy of the Asturian contrasting with the exuberance of the average Spaniard. The harbours are numerous, but none are of great importance, their defective installation and the excessive pilotage-dues contributing to arrest development. The rivers issue from the mountains mostly as torrents, and are navigable only in the very last few miles of their course. The roads, except in the immediate neighbourhood of the larger towns, are kept in ill-repair, and the railway-system may be regarded as still in its infancy. The population is scanty, and most of the native-born labourers, even when employed in various industries, devote much of their time to work in the fields.

On the whole, the solid geology of the province is made up of Palæozoic formations, with a few patches of younger strata along the coast. The Cambrian and Silurian predominate in the west, the Devonian occupies the lower valleys of the Nalon and the Narsea east of the Cambro-Silurian belt, while the Coal-measures extend over the entire eastern portion of the province, being overlain in the districts of Aviles, Gijon and Villaviciosa by Triassic, Jurassic and Cretaceous rocks. Exposures of Permian strata have nowhere been observed.

The Asturian coal-field extends from east to west, parallel with the coastline for some 93 miles, while its breadth from north to south measures rather more than 37 miles. Workable seams are confined to the western part of the coal-field, the really prosperous mines being clustered in two chief basins, those of the Nalon and its left-bank tributary the Caudal. The Devonian formation cuts off the coal-field on the west and south, while northward the Coal-measures dip below the Trias and the Cretaceous. Trial-borings (with the view of striking the possible extension of the coal-field) have been put down through these newer rocks at various localities. The coal varies in character from south-west to north-east, becoming in that direction increasingly rich in volatile matter. Conversely the Coal-measure

conglomerates decrease in the same direction, giving gradually place to continuously finer grits, and at last to shales. By means of the horizons of unconformity three principal divisions are recognized in the Asturian Coal-measures; they are, in ascending order, as follows:—(1) The Lower or Millstone Grit series, conformably overlying the Devonian, and in a total thickness of 2,920 feet containing only seven workable coal-seams (altogether 12¼ feet of coal); (2) the Middle series, the basal portion of which still belongs to the Millstone Grit, with forty-five workable seams (93 feet of coal); and (3) the Upper series, containing, in a total thickness of 1,082 feet, fourteen seams with altogether 25¼ feet of coal. The upper division occurs only in the Lama district. Seams less than 20 inches thick are not classed as workable, and over the whole the average thickness of 2 feet is fairly constant. The palæontological evidence would assign the entirety of these Coal-measures to the Westphalian, and although Stephanian strata are to be found in the Asturias they are not sufficiently productive there to rank as of any great importance.

The Hercynian movements which beset the Asturian region in Westphalian and pre-Triassic times, and the later movements, which took place between the deposition of the Lower Cretaceous and that of the Upper, compressed and contorted the Coal-measures most intensely, with the result that these are packed into about a tenth of the area which they originally occupied. The dip is generally pretty constant in the neighbourhood of 58 degrees. Of the numerous ore-deposits, which are known to exist in the province, those of iron, copper and mercury are alone worked at present; but manganese has been found in four separate localities, antimony at several points along the Cantabrian range, zinc, cobalt, and nickel in two localities respectively, gold at Tapia, and plumbiferous ore at San Martin de Los Oscos.

The Stephanian coal-seam of Arnao, 33 feet thick, is the only seam worked in the Asturias by means of a shaft; but when the proved extension of the coal-field below the Mesozoic strata comes to be worked, there will inevitably be plenty of other examples of deep pit-workings in the province. The tubs are mostly drawn by mules; the coal, as hewn in the mine, is usually so dirty that 65 to 70 per cent. of it must needs pass through the washing-plant. The slimes are generally tipped into the river, but in some few cases they are compressed into a heap and coked. The washed coal is sorted into five different sizes, the smalls averaging 43·2 per cent. of the whole. The manufacture of briquettes or compressed fuel has been little developed so far, and modern coke-ovens are only to be found in connection with ironworks, etc. Night-shifts are hardly ever worked; meals are always taken above bank, wherefore, although the Asturian miner's day lasts from 10 to 12 hours, he spends so much time going to and fro, that the effective working hours are reduced to six or seven. Not only is the labour poor in quality, but it is insufficient in quantity to work the seams out thoroughly. Moreover, the Asturian miner is so jealous of strangers that he contrives to make life a burden to any intruder from another province. With a view to the development of the coal-field, however, it may prove necessary to establish something in the nature of compounds, wherein to lodge workpeople brought from other parts of Spain. Meanwhile, mutual benefit societies and co-operative stores have been established, and are making considerable headway in the mining districts of the Asturias.

The major part of the Asturian coal-output consists of bituminous varieties, averaging from 30 to 35 per cent. of volatile matter. In the Quiros and Turon districts the coal contains only from 15 to 25 per cent. of volatile matter. Anthracite occurs at Pola de Leña, but on the whole it is so scarce as to bulk only for 10,000 tons in the total annual output of the province. The composition of Asturian coal being what it is, the recovery of ammonia as a bye-product from its distillation is a matter of considerable importance, the more so that there is a good market for sulphate of ammonia in Spain. The coal is generally somewhat pyritous, the percentage of sulphur in it ranging from 1 to 4. Comparative experiments have been made with Cardiff, Newcastle and Asturian coal at the Ferrol Arsenal; they have shown the superiority of the Cardiff mineral as a steam-coal, and its price would have to be 15 per cent. higher in a given market than that of the Asturian coal, for the latter to secure the preference of the consumer. The average heating power of the Asturian coal is from 6,800 to 6,900 calories; its specific gravity ranges from 1·23 to 1·30; and, in the case of carefully screened and washed mineral, the percentage of ash is fairly comparable with that yielded by Cardiff coal. The average yield of coke from the various Asturian coals is 67 per cent. and the best-reputed coking coals are got from the Turon and Mieres mines; most of the coke produced is consumed within the province itself. Prime costs differ greatly, ranging, according to circumstances, from as little as 8 pesetas to as much as 18 pesetas (6s. to 13s. 6d.) per ton. The annual output has not varied much within the last seven years; in 1903, it amounted to 1,418,423 tons, but probably another hundred thousand tons would have been wrought, had it not been for the strike which lasted over many months of that year in the Langreo district. The amount of workable coal existing in the Asturias, at depths from the surface not exceeding 1,640 feet, is estimated at 2,400 million tons.

In the course of a long discussion of the markets available for Asturian coal, stress is laid on the desire predominant in Spain to make the country independent of imported coal. Already, it would seem, has British coal been all but banished from Santander, Vigo and Coruña; and now great efforts are being made to displace it in Bilbao by Spanish coal. The Government have recently forbidden the use of foreign coal in the navy and the arsenals, and the projected raising of the import-duties is expected to help on the movement.

Notwithstanding the abundance of iron-ore in the province of the Asturias, the total output for the year 1903 did not exceed 75,000 tons, one reason being that only those deposits that are situated near a railway-line or a seaport can be worked at a profit under present conditions. The blast-furnaces already set up in the province, consuming annually about 146,000 tons of ore, must therefore look elsewhere for much of their supply. The most important of the Asturian iron-ore deposits are the Lower and Middle Devonian hæmatites, and these yield a mineral containing (on an average) 50 per cent. of metallic iron. The percentage of silica is considerable, ranging from 10 to 25 per cent., but phosphorus and alumina are present in quite insignificant proportions. In the neighbourhood of Cape Peñas, the deposits comprize no less than six bands of ore, attaining in some cases a thickness of 20 feet: these will be easily worked by means of adits driven in the hill-sides. In the Silurian of the Salas district are considerable deposits of iron-carbonates and hæmatites; and the total quantity of ore

in sight is estimated at 100,000,000 tons. Only four important iron-and-steel works exist at present in the province, but the details given by the author suggest the inference that there will shortly be a considerable development of the metallurgical industry in that region. There are zinc-smelting works at Arnao, and copper-smelting works have been quite lately set up at Lugones. No less than three works deal with the mercury-ore got from the metalliferous breccia mined in the Mieres district. After the mercury has been extracted, the residues are utilized for the manufacture of sulphide of arsenic. L. L. B.

GALENA-DEPOSITS OF MAZARRÓN, SPAIN.

Die Bleiglanzlagerstätten von Mazarrón in Spanien. By RICHARD PILZ. *Zeitschrift für praktische Geologie,* 1905, *vol. xiii., pages* 385-409, *with* 21 *illustrations in the text.*

Mazarrón is a town of some 20,000 inhabitants, in the province of Murcia, about 4½ miles distant from the Mediterranean, and is linked up with the harbour of the same name by means of a light railway. The nearest stations on trunk-lines (Cartagena and Tofana) are respectively 15 and 16 miles away. Above the town soars the 1,000 feet high volcanic cone of San Cristobal, reminiscent of the great Tertiary eruptions whch took place all along the fissure-belt of South-western Europe and Northern Africa. The framework of the district is made up of Archæan crystallines: muscovite-schists, phyllites, saccharoídal limestones, and dolomite, which of course were rudely disturbed by the tectonic phenomena that culminated in the above-mentioned vulcanicity of Tertiary times. The contact-zone between the Archæan rocks and the eruptives is frequently characterized by the occurrences of irregular deposits of brown iron-ore, compact or earthy, containing up to 53 per cent. of iron and 20 per cent. of manganese. Phosphorus, when present, occurs in infinitesimal proportions. In places these deposits admit of profitable working. Some of the altered eruptives furnish an impure alunite, which yields, on an average, for every 15 tons of crude material, about 2 tons of alum. The origin of this alum-stone is connected with the solfataric phase of the Tertiary vulcanicity, the moribund efforts of which appear to be now vented in discharges or blowers of carbon dioxide within the Mazarrón mines. These are often so continuous and voluminous as to make breathing impossible in the workings, and to entail more or less prolonged stoppage of mining operations. In reality, as regards blowers, we have here a case of the occlusion of considerable quantities of carbon dioxide within the eruptive rocks when they were still fluid; the gas underwent considerable compression after the solidification of the rocks, and now expands with explosive force on its release by the miner's pick. Both the Archæan rocks and the Tertiary eruptives are, in part, mantled over by Pliocene and Quaternary sedimentary deposits.

The mining field of Mazarrón covers an area of some 20 square miles, but in only a small portion of this are workable galena-deposits met with, chiefly in the neighbourhood of the Tertiary dacites. Thus the galena of Mount San Cristobal, Los Perules and Pedreras Viejas, occurs (1) as veins in dacite; (2) as veins in the masses of mica-schist, amphibolite, dolomite and quartzite, included within the eruptive rock; and (3) as veins at the contact between the dacites and the Archæan crystallines. There-

seems to be little doubt, that it was the fissures brought about within the eruptive masses by their contraction on cooling, that formed the *locus* of deposition of the metalliferous particles precipitated from the thermal solutions which percolated through these fissures. The contraction-fissure theory accounts for the observed diminution in the number of veins as the depth from the surface increases. But, where occasional masses of schist are embedded in the eruptive rock, there is a concurrent and significant increase in the number of veins. It is true that some few of the veins demonstrably infill fissures caused, not by contraction, but by later disturbances of the rocks. These disturbance-fissures, however, have a disagreeable habit of cutting across the best metalliferous veins, which then pinch out entirely beyond them, or, to speak more exactly, end up against them.

The general strike of the plumbiferous veins lies between north and east; their dip is in almost every case a steep one; and their thickness (premising that it rarely exceeds 4 inches in the case of simple fissures), is extremely variable. But many veins coalesce in such wise that the thickness of most of those that are now being worked usually ranges from 20 to 40 inches, while the Esperanza vein bellies out in places to 16 feet or so, and averages 10 feet. In the Romano y Lagueñas vein, a thickness of more than 26 feet has been measured from hanging-wall to foot-wall at some points, the average being 6½ feet. The greatest thickness noted in the present workings on the Prodigio vein is 20 feet. In extent, the coalescent veins have been proved over distances varying from 720 to 1,800 feet; while the simple fissures can rarely be followed for more than 165 feet. In regard to the depth from the surface, there is little expectation of finding many workable fissure-veins below the 1,640 feet level.

The galena is, invariably but irregularly, argentiferous (containing on an average from 0·13 to 0·19 per cent. of the precious metal), although it is not, on the whole, remarkable for its purity, 81 per cent. of lead being perhaps the most favourable assay that could be quoted. The percentage of silver seems to increase in the same ratio as the amount of chalybite in the gangue, while it diminishes where pearl-spar wholly or partly displaces the iron-mineral. It may be mentioned here that chalybite, and passage-minerals between this and dolomite are by far the most abundant constituents of the gangue, while heavy-spar, colourless quartz, and gypsum (although common) play a less conspicuous part. Near the surface, zinc-blende occurs, more especially in the Esperanza and Pedro veins: it does not carry much silver. Iron-pyrites and marcasite are found nearly everywhere in the veins, and contain a great deal more silver than the blende. Copper-pyrites is occasionally met with, while the abundant occurrence of magnetic iron-ore in the upper levels is highly characteristic. The brown iron-ore, which sometimes occurs at the outcrop of the plumbiferous veins in sufficient quantity to be worked (as at the Visto Alegre mine), is the chief decomposition-product of the more deep-seated ores; next in abundance come the carbonates of lead and zinc.

The mineral-industry in the district dates from a time lost in the grey mists of history, and it reached a high pitch of prosperity in the reign of the Roman Emperor Claudius. Not only do the vast heapsteads and the remains of ancient smelting-works bear silent witness to this, but the underground workings and the fairly deep shafts sunk by the Romans are an additional testimony to their mining activity during at least four centuries. A great revival has taken place since the early seventies of the nineteenth century,

when the primitive system of working was, to some extent, displaced by thoroughly modern methods.

Besides certain other disadvantages, some of which have already been mentioned, the high temperature prevalent in the mines (due probably to decomposition-processes going on within the rocks) must be taken into account. On the other hand, the main lodes are fairly rich and close together in the upper and middle levels; the country-rock is not especially hard: and labour is cheap. The men work in 12 hours' shifts below bank, and from sunrise to sundown above bank. Consequently the prime cost of the ore ready for delivery to the smelters is low. Syndicating of the mines in such a fashion as to group them together under one management is one of the improvements suggested by the author. He further points out that the heavy royalties payable by lessees to mineral-owners press very hardly on the industry. In the year 1904, about a score of mines were at work, employing altogether 2,870 persons; and the total output of galena for that year from Mazarrón amounted to some 30,100 tons. But the statistics of output are vitiated by the fact that, in order to evade to some extent the 3 per cent. tax *ad valorem* payable to the State, many of the mines conceal from the authorities their actual output. This secretiveness is a policy characteristic of most mining districts in Spain, with the result that the official statistics of the mineral output of that kingdom are (to put it mildly) never quite accurate. Most of the Mazarrón ore is smelted in works situated near the harbour of that name, and the remainder is shipped off to Cartagena to be smelted there. L. L. B.

SULPHUR OF COTO MENOR, MURCIA, SPAIN.

Minas de Azufre del Coto Menor de Hellin en Minas (Albacete). By JAVIER BORDIU. *Revista Minera, Metalúrgica y de Ingenería*, 1904, *vol. lv.*, *pages* 333-336.

The sulphur-deposits in the locality of Hellin (province of Murcia, Spain) are numerous, but, up to the present time, only two have been worked, at Lorea and Coto Menor.

The strata are of marine formation of the Miocene period, and the continuity, apart from the effects of denudation, is broken only by an isolated trachytic outcrop. The section of strata is as follows: Rounded siliceous stones, embedded in fine sand, 10 feet; calcareous marls, interstratified with thin beds of coarsely grained limestone, 116 feet; beds of similar composition but of a dark tint (due to the presence of bituminous and sulphurous matter), 33 feet; followed by the sulphur-beds, which are interstratified with limestones, marls, clays (more or less bituminous) and gypsum.

The origin of the sulphur has been accounted for in various ways, one theory attributing the deposition to the action of geysers, from which sulphuretted hydrogen and gaseous hydrocarbons have been emitted, the decomposition of the sulphuretted hydrogen by water resulting in the sulphur being deposited. In another theory, mud-volcanoes take the place of the geysers, and the author apparently inclines to this latter view, pointing out that, putting aside the supposition of the mud-volcanoes, it is difficult to account for the presence of the clays. The trachytic outcrop has been held to be connected with the origin of the sulphur, but cogent reasons are

given for believing that its deposition, at least in its present position, was subsequent to the formation of the surrounding strata in which the sulphur-beds are found.

The sulphur-beds, dipping 17 degrees to the north-west, are fourteen in number; but only ten of these are workable, their extraction being carried out by workings at four different levels separated from one another by about 10 feet, the total thickness of the mineral in each face being about 3 feet.

The method of working, ventilating, and unwatering the mines is briefly described, electric motors being a prominent feature of the undertaking, the current being generated by dynamos worked by a steam-engine of somewhat ancient date. The mine-water carries sulphuretted hydrogen in solution, and the gas, set free in the sump, is removed by a small centrifugal fan.

At the surface, the mineral, after slight washing, is roasted in Gil furnaces, the crude sulphur thus obtained, after being refined by retorting, is sent into the market in the form of roll-sulphur and flowers of sulphur. Up to the present time, 50,000 tons of mineral have been extracted, the sales of sulphur representing 50 per cent. of the consumption in Spain.

H. D.

RADIO-ACTIVE AND URANIUM-BEARING MINERALS IN SPAIN.

(1) *Minerales radioactivos españoles; and* (2) *Emanación de los Minerales uraníferos de Colmenar Viejo. By* José Muñoz del Castillo. *Revista de la Real Academia de Ciencias de Madrid,* 1904, *vol. i., pages* 423-427 *and* 442-444, *and* 2 *plates.*

The author made radiographic and electroscopic experiments with a chalcolite (a hydrated phosphate of uranium and copper) from Colmenar Viejo, and with a similar mineral, but containing probably less uranium, from Torrelodones; and he found that they yielded results more closely comparable with those obtained by check-experiments from metallic uranium and thorium oxide, than with those obtained from a specimen of samarskite (a rare yttrium-niobium-uranium mineral found in the United States of America). The results lead him to infer that in the Spanish minerals, as in the Joachimsthal pitchblende, the uranium-compounds are intermixed with an appreciable proportion of more electrically-active substances.

Further experiments, made with specimens from Colmenar Viejo alone, show that the mineral from that locality can be made to produce the phenomenon improperly termed "induced radioactivity," and it is inferred that it contains either radium, or actinium, or thorium. L. L. B.

PISOLITIC IRON-ORES OF THE BERNESE JURA.

Le Fer et le Terrain sidérolithique dans le Jura bernois. By Ernest Fleury. *Bulletin de la Société fribourgeoise des Sciences naturelles,* 1904, *vol. xii., pages* 29-33.

Reviewing briefly the mineral-industry of Switzerland, the author points out the general poverty of that country in metalliferous ores. It is true that gold is still being got from the deposit of Gondo in the canton Valais, but the silver, nickel, cobalt, copper, lead, arsenic and manganese-ores do

not now form the object of mining operations. In most cases, indeed, the deposits are so scanty as not to repay working. Among the causes of this general poverty in metalliferous ores the author classes the almost complete absence of eruptive rocks and of Palæozoic deposits; moreover, the intensity of the Alpine folding enhances greatly the difficulty of mining operations. Bituminous coal does not appear to occur in Switzerland, but the occurrences of graphite, lignite, anthracite, and peat, as also the famous asphalt of Val de Travers, are at least worthy of passing mention. Moreover, at Bex and Rheinfelden enough salt is got to supply the needs of the whole country.

The only really considerable mineral product of the country is iron. Excellent deposits of iron-ore occur at Chamoson, Chemin and Charrat, in the canton Valais, also in the canton Graubünden; but the main site of the siderurgical industry is the valley of Delémont in the Bernese Jura. Here about 6,000 tons of *bohnerz*, or pisolitic hydrated sesquioxide of iron, are extracted annually from beds lying at the base of the Upper Eocene, or the Siderolithic formation. This Siderolithic formation, where it occurs at the bottom of combes or synclines, is clearly stratified, seven main beds being distinguished in it; the iron-ore is mostly concentrated in the bottom-bed, where it is worked. In other instances the Siderolithic formation fills pockets in the underlying Kimmeridgian, Portlandian, or Sequanian deposits, as the case may be. It is but seldom that these pockets go down as deep as the Oxfordian. The pisolitic grains represent the result of accretion around a nucleus, usually of organic nature; and there appears to be no doubt that organisms have played an important part in the genesis of the ore-deposit. The average composition of the ore is, according to analysis, as follows:—60 per cent. of sesquioxide of iron; 13 per cent. of silica; and 15 per cent. of alumina. The yield in pig-iron is from 40 to 42 per cent. The single blast-furnace is fed with coke, Jurassic limestone serving as the flux. The slag is utilized in cement- or brick-manufacture. In 1897, there were still four mining-shafts in full activity; now there are only two, going down to the depth of 288 and 361 feet respectively. The author forecasts the early extinction of this remnant of an ancient industry, dating from the times of the Romans, traces of whose forges have been found. L. L. B.

COAL-BEARING BEDS IN THE BALKANS.

(1) *La Formation charbonneuse supracrétacée des Balkans.* *By* L. DE LAUNAY. *Annales des Mines*, 1905, *series* 10, *vol. vii.*, *pages* 271-320, *with* 7 *figures in the text and* 1 *plate;*

(2) *Sur quelques Fossiles de la Région à Charbon des Balkans.* *By* H. DOUVILLÉ. *Annales des Mines*, 1905, *series* 10, *vol. vii.*, *pages* 321-325; *and*

(3) *Sur quelques Empreintes végétales de la Formation charbonneuse supracrétacée des Balkans.* *By* R. ZEILLER. *Annales des Mines*, 1905, *series* 10, *vol. vii.*, *pages* 326-349 *and* 1 *plate.*

The first memoir embodies the results of a journey which the author made into Bulgaria in September, 1904, presumably with the benevolent sanction of the French Government, but at the formal request of that of Bulgaria. From the geological point of view, the general conclusions at which he arrived are as follows:—From the Carboniferous down to the end of Tertiary time a geosynclinal has existed at recurring intervals on the site

of the Central Balkans. Within it have been deposited gritty and shaly sediments, similar in aspect and with similar accumulations of plant-remains, probably laid down in lakes or long brackish lagoons. Thence originated in the first instance the Carboniferous anthracites of the Isker valley, of abnormal hardness and unusable, at present at all events. Then, after the interruptions caused by temporary and local inroads of the sea, during Triassic, early Jurassic, and Cenomanian time, came the coal-deposits, which form the main subject of the memoir; these were succeeded by the deposits of plant-remains dispersed among the supra-Cretaceous and Eocene grits of the Flysch Series; and these again by the Neogene lignites, which are perhaps the most important source of mineral fuel in Bulgaria. There are very many gaps in the rock-succession, as the area remained for a long time above sea-level; and thus absence of deposition was accentuated by the atmospheric erosion of previously-formed deposits. In the country which lies between Trevna and Slivno occurs a coal-bearing formation, apparently unrepresented elsewhere in the Balkans by beds of a similar facies. It is of lacustrine and brackish-water character, with marine intercalations in the Bela district, at any rate. At the base is a group of several thin, discontinuous, carbonaceous beds, consisting of bituminous coal rich in volatile matter, which, after hand-picking, shows a heating power equivalent to 8,000 calories. Higher up in the series occur dispersedly a few lenticles of similar coal, broader, but very short. This formation is of Campanian or Upper Senonian age. In the midst of it appear accidental intercalations of older strata, Cenomanian limestones with *Orbitolina* and *Radiolites*. The whole of the above-mentioned rocks were affected before the Flysch period; and then, after the Flysch but before the Neogene, by a first series of movements, which, in the Central Balkans, have overturned and thrust northwards in the direction of the pre-Balkanic plateau all deposits of pre-Neogene date. Then a series of longitudinal dislocations, with consequent sagging, originated the deposition of the lignite-bearing Neogene sediments in a well-marked *cordon* of basins. The continuation of these movements, in association with recurring outbursts of volcanic activity, caused local disturbance of the Neogene deposits themselves. A curious circumstance, to which the author surmises that he may be the first to draw attention, is that, in a great portion of the Balkanic region traversed by him the actual watershed lies a few miles to the north of the orographic crest-line; the rivers, flowing southward, cut through this crest in deep gorges. This phenomenon is characteristic of the zone where the coal-bearing formation assumes its greatest breadth; it is not to be observed on the west towards Kasanlik, or on the east towards Slivno. In his brief historical summary of the question, Prof. de Launay remarks that the coal-bearing strata have long been known and actively explored. Their existence appears to have been first mentioned in print in 1867, but the first detailed description dates from 1871. A few shallow pits have been sunk and adits driven, by the natives of the districts concerned, on the coal-outcrops; but the sole locality where operations have been conducted on a really industrial scale is the Prince Boris mine at Radevtsi. Here, since the year 1897, a French syndicate has been carrying on exploration-work. It is true that, for want of a market, operations have been provisionally suspended, but the projected new railway from Tirnovo, which will run through the coal-field, will doubtless remove this difficulty before very long.

The geology of the Central Balkans is described in sufficient detail, and the author then proceeds to deal with the coal-bearing formations in particular. The Senonian carbonaceous series consists, broadly speaking, of grits and shales with some conglomerates, and, though few and far between, bands of marl or limestone, among which are locally intercalated lenticles of coal. The series is, on the whole, regularly bedded. The presence of brackish-water fossils and the local intercalation of marine bands at Bela probably implies the occasional invasion of sea-water during the process of sedimentation. In consequence of repetition of the beds by folding, it is rather difficult to determine the precise thickness of the entire carbonaceous series, but it can hardly be less than 6,000 feet and may possibly be double or treble that amount. It occupies a belt trending east and west for 40 miles or more, sometimes north and occasionally south (but more often north) of the watershed, and nearly always north of the crest-line of the Central Balkans. This belt varies in width from 1¼ miles to a maximum of 10¼ miles. The great disturbances, dislocation, contortion, shearing, overthrusting, overturning and erosion, which the coal-bearing strata have undergone since their deposition, are discussed at some length.

Turning then to the consideration of the principal outcrops of coal and the fossiliferous bands, the author takes as the type of the former the above-mentioned Prince Boris mine at Radevtsi. This includes two distinct deposits, separated one from the other by a ridge of Archæan and Triassic rocks: they are so different in character that they suggest, if not difference in geological horizon, at all events difference in conditions of sedimentation. The "Amélie zone," a narrow belt of Senonian wedged in between the Archæan and the Trias, is perhaps the richest in coal of any yet traced in the Balkans, while the "Caroline zone" appears to be of small industrial value. In the former three seams have been proved dipping 60 degrees; but their apparent regularity masks considerable irregularity, as Prof. de Launay shows in detail. However, they have been traced for 1,200 feet or so along the strike, and for 164 feet in vertical depth. The "Amélie type" of deposit, a group of thin seams occurring near the base of the coal-bearing series, is analogous to those proved on the east of the coal-field, from Bukova to Chumerna and Kachutka, near Bela; while the "Caroline type" recalls the lenticles which occur farther away from the Archæan rim, towards the north, and probably higher up in the series. The three lenticles of the "Caroline zone," similarly situated in regard to one another, but unconnected one with the other, are in immediate contact with the Triassic dolomite.

Eight analyses of coal are tabulated, and it is shown that these Bulgarian coals contain very little sulphur. Certain experiments would seem to imply that coke might be manufactured from them. Generally speaking, the mineral is very friable, and makes much dust in the working. It is, too, irregularly mixed with shale. Mining operations are facilitated by the outcropping of the seams (which usually dip from 40 to 60 degrees) on the mountain-slopes. Timber abounds, as much of the country is still clothed with magnificent forest; but the habitual occurrence of fire-damp in the mines is a drawback to be reckoned with. The prime cost, at the pit, of one ton of hewn coal varies from 5s. to 8s. 4d. The cost of transport is, however, at present prohibitive; but, once the new railway is completed, it is expected that freights from Radevtsi to the banks of the Danube will not exceed 5s. 10d. to 6s. 8d. per ton. Whether the coal will find a sufficient market, when it gets that far, remains to be seen.

Prof. Douvillé describes the fossil mollusca, etc., found in the coal-bearing and associated strata, while Prof. R. Zeiller describes the plant-remains, figuring among them some new species. The palæontological and palæobotanical evidence appears to confirm in every respect the conclusions arrived at by Prof. L. de Launay, as to the age of the beds.

L. L. B.

UPPER CARBONIFEROUS FLORA OF THE YENTAI COAL-FIELD, SOUTHERN MANCHURIA.

Notiz über die obercarbonische Flora des Steinkohlenreviers von Jantai in der südlichen Mandshurei. By M. ZALIESSKI. *Verhandlungen der russisch-kaiserlichen mineralogischen Gesellschaft zu St. Petersburg*, 1905, *series* 2, *vol. xlii.*, *pages* 485-508, *with* 15 *figures in the text.*

The plant-specimens, upon which this memoir is based, were collected by Mr. J. Edelstein in December, 1903, from the débris brought up from a depth of 485 feet or so, from a shaft-sinking then in progress. This depth indicates the horizon to be that of No. 7 seam, industrially speaking the only important seam out of the ten or more which the Russian geologists accept as existing in the Yentai series. Three species of ferns are described (and figured), and one each of *Calamites*, *Sphenophyllum*, *Lepidodendron*, *Stigmaria*, *Cordaites*, *Trigonocarpon*, and *Plagiozamites*. They constitute a typical assemblage of Upper Carboniferous age, very near the border-line between the Carboniferous and the Permian floras.

The Coal-measures of the neighbouring coal-field of Pönn-hsi-hu have already been characterized by Prof. R. Zeiller as passage-beds between the Carboniferous and the Permian; and there seem to be good grounds for regarding the Southern Manchurian coal-fields as well as those of Kaiping (in Chili province) and Shansi province in Northern China, as dating all from the same period. Palæobotanical evidence in favour of this assumption is cited.

L. L. B.

COAL-FIELDS OF JAPAN, PECHIHLI AND MANCHURIA.

Les Charbons du Japon, du Petchili et de la Mandchourie: Notes de Voyage. By CH. E. HEURTEAU. *Annales des Mines*, 1904, *series* 10, *vol. vi.*, *pages* 151-209, *with* 12 *figures in the text and* 1 *plate.*

The materials upon which this memoir is based were mainly collected by the author on the spot, in the latter half of 1903, and he supplemented them with information derived from the publications of the Japanese Geological Survey and other official bodies.

Japan.—The study of the Japanese coal-fields is much simplified by the fact that the coal-mining industry is restricted to comparatively small areas, the island of Kiushiu alone accounting for 82 per cent. of the total output of the Japanese Empire, while the northern island of Hokkaido (formerly known as Yezo) contains a long outcrop of coal which bulks for another 10 per cent. in the total output. All the first-quality coal comes from these two islands; the inferior coal, not good enough for the export-trade, comes from the provinces of Hitashi and Nagato in the Main Island (Honshu).

In the north of Kiushiu, a group of synclines, the axes of which trend north-westward, forms the coal-basin of Shikuho, which furnishes over half of the total Japanese output. South-west of this is the Karatsu basin, wherein the coal-outcrops also strike north-westward, but no longer form regular synclines, and dip south-westward. South-east of these again are the Miike mines, the most important and the most famous in all Japan. On the much indented western coast-line of Kiushiu, the little island of Amakusa yields a certain amount of very useful anthracite; the islet of Takashima in the roadstead of Nagasaki has a comparatively important output of coal; while very little coal is worked on the island of Matsushima. The geological age of all these coals is uncertain: except in a few localities, the coal-bearing beds of Kiushiu rest directly upon crystalline schists or eruptive rocks, and the seams have been often changed into coke (*senseki*) by the contact-metamorphism resulting from the intrusion of igneous dykes. Such evidence as there is points to the coal being at the earliest of Cretaceous age, and, more probably, Tertiary.

In the Shikuho basin, the workings are confined to a series of parallel outcrops, striking north-north-westward, and dipping 12 to 15 degrees eastward: they all comprize two main seams, the lower of which (3½ to 5 feet thick) yields a pure coal, while the upper (5 to 8 feet thick) is frequently altered into natural coke or into anthracite, and usually yields a rather dirty coal. Analyses are tabulated of some of the coals, and that which is considered the best, from Namasuta, shows the following percentages:—

	Lower Seam, 5 Feet Thick.	Upper Seam, 8 Feet Thick.
Volatile substances	42·50	41·34
Ash...	3·16	5·71
Hygroscopic water	1·66	1·41
Coke	52·68	51·54
Sulphur	0·81	0·38
Calories	7,990	7,570

In the Karatsu basin, the seams are generally thin, averaging perhaps at most 3½ feet, but the mineral is of good quality. In the Miike basin, the beds dip on the whole 8 to 10 degrees south-westward, striking at first south-eastward and then curving round southward as the granite-massif is approached. Eight seams are recognized, the lowermost two being the most important: the bottom, or so-called Eight-feet, seam (in reality varying in thickness from 1 to 20 feet) is the only one of the two that is at present worked. The next seam above, averaging 6 feet in thickness, has never been much worked at any time. The Miike coal is very friable, and contains a good deal of sulphur: in fact, owing to the oxidation of the pyrites in it, the coal has a general brownish tinge, which sometimes becomes almost red. Nevertheless, putting the "red coal" aside (which is burnt only at the pit), the Miike coal is regarded as one of the best in Japan, owing to its great heating power. An average analysis yields the following percentages: volatile substances, 40·10; ash, 6·84; hygroscopic water, 0·65; sulphur, 3·14; coke, 53; and calories, 8,100. The output from the five pits at work amounted in 1902 to nearly 1,000,000 tons.

The Takashima basin includes, besides the islet of that name, two other islets in the roadstead of Nagasaki (Hashijima and Yokoshima). Four principal seams are recognized; and, in 1903, preparations had been made

for working the coal beneath the sea, and in fact joining up by submarine extensions the collieries on the two first-named islets. The output in 1902 did not fall far short of 200,000 tons; the coal is remarkably free from impurities, and analyses communicated to the author at the mines showed more favourable results than the analyses tabulated in the official publication on *The Geology of Japan.* The Amakusa anthracite (three seams, each ranging in thickness from 2 to 6½ feet) is mixed with Takashima bituminous coal into briquettes for use in the Imperial Japanese Navy. In places, where the seams are cut by liparite-dykes, the anthracite has been metamorphosed into natural coke.

In Honshu (or the main island), the coal of Nagato is of Liassic or more probably Rhætic age (recalling in this respect the Tongking deposits); it occurs in comparatively thin seams, two of which, 2 and 3 feet thick respectively, yield an annual output of 250,000 tons. The mineral is of poor quality, and is used up locally. On the other hand, the Iwaki deposit crops out parallel with the coast-line of Honshu, over a length of 25 miles, but yields a coal containing so much hygroscopic water that it forms a very uneconomical fuel. In the centre of the belt, two seams (115 feet apart) 3½ and 6 feet thick respectively, are worked; they thin out northward and southward, finally giving place to more or less black shales. The annual output, of about 450,000 tons, is consumed locally and in the north-eastern ports of the island.

The principal coal-deposit of Hokkaido strikes north and south among the Tertiary sedimentaries, which rest upon the volcanic *arête* that strikes in the same direction through the island. The Tertiary strata are folded into very marked anticlines and synclines; and, although most of the coal-seams in Hokkaido are considered to be of Tertiary age, Upper Cretaceous fossils are said to have been found in association with some of them. The three most important mines in the island are those of Yubari, Poronai, and Sorashi, situated in three parallel valleys which cut the great 50 miles coal-bearing anticline: their united output in 1902 exceeded 825,000 tons. Three or four principal seams, varying in thickness from 3½ to 14¾ feet respectively, are recognized. At the Sorashi mine the dip of the beds is particularly steep. It produces a coal intermediate in quality between those of Yubari and Poronai: average percentage-analyses of these two coals are appended:—

	Yubari Coal-seam.	Poronai Coal-seam.
Volatile substances	42·89	42·19
Ash	4·57	3·92
Hygroscopic water	1·46	5·09
Coke	57·11	48·80
Sulphur	0·31	0·25

The Yubari coal is regarded as the best, being dry, pure, and very hard. The reserves of coal in sight in the island of Hokkaido are estimated at 600,000,000 tons. The coal now got there is mostly shipped at Muroran, for use as steam, gas, and bunker-coal in the factories and harbours of the Empire.

By far the greater number of the Japanese mines are worked by pits sloping down from the outcrop, but in the newer collieries vertical shafts have been sunk to a good depth. Most of the hewing is done by hand, and generally without shot-firing. The Ingersoll-Sergeant type of coal-

cutter was tried at the Gotoji mine, but did not yield economically satisfactory results, owing to the friability of the coal and the dip of the seam. The Kiushiu mines are often very fiery, and single-gauze lamps are in use there. As the miners generally take one day off in every three, a colliery which has on its books say, 3,000 men, will only have 2,000 continuously at work day by day. The year is reckoned to contain 330 working-days. The cost of labour per ton of output at Miike does not much exceed 10d., but in the Shikuho coal-field it varies from 1s. 11d. to 2s. 7d.; and the prime cost of a ton of coal at the pit-mouth in the first-named coal-field averages 4s. 3d., while in the latter it averages 5s. 11d. Free on board at Moji harbour, the all-round cost of coal from the most distant collieries of Shikuho is reckoned by the author at about 8s. 9d. The selling-prices, free on board, in various Japanese harbours, ranged in the course of 1903 from 10s. 10d. to 19s. 3d., the prices at Moji being the most advantageous from the buyer's point of view; from that harbour, indeed, is shipped more than 62 per cent. of the total Japanese export of coal. China and Hongkong between them take nearly three-quarters of this total, and the Straits Settlements take more than an eighth.

Pechihli.—The only coal-field so far worked on a really industrial scale in Pechihli, is that of Kaiping, through which runs the Imperial Chinese Railway from Peking to Shanhaikwan and Newchwang. The basin seems to form an irregular ellipse, the major axis of which trends east and west, while the outcrops are more especially seen on the northern rim of the ellipse. There the coal-seams overlie a limestone of Carboniferous age, which itself rests upon a series of metamorphosed Cambrian grits and limestones (Sinian of Richthofen). On the southern rim the outcrops are largely masked by drift-deposits, and coal there has only been struck in the Liushi area. The total length of the known coal-belt, from Tongshan to the eastern extremity of the outcrops, is about 25½ miles: seventeen seams have been proved, all dipping steeply towards the centre of the basin, the dip sometimes approaching the vertical, and going even beyond that and becoming a reversed dip. The workings are in the hands of an Anglo-Belgian syndicate, which also controls the wharves of Shinwangtao, an open port a little to the south of the Great Wall. A branch-line runs to the harbour from the main railway; but a great number of the Belgian shares in this syndicate are said to have been purchased by the Russian Government in 1903. The output of coal from the Kaiping basin in 1902 exceeded 700,000 tons. The total thickness of measures intervening between the thirteen seams which are worked is 918 feet, and the seams that are most actively worked are No. 3 (10 to 14¾ feet thick), No. 5 (3¼ to 4½ feet), and No. 9 (9 to 11½ feet). The two last-named yield the purest coal, but No. 5 seam, the best of all, is unfortunately well nigh worked out. Some features of the workings at Tongshan are described, where continuous pumping by five pumps is necessary, and analyses of the coal are tabulated. The mineral, even that shipped at Shinwangtao, is mostly used in China, and only a small proportion goes to Hongkong. The Kaiping coal, although inferior to the Japanese export-coals in many respects, is a less wasteful steam-producer, as it contains a smaller proportion of volatile substances (33 per cent., as compared with 40 per cent. or more). It makes a very large quantity of "small," which is consumed locally.

Manchuria.—In Manchuria nearly all the known outcrops of coal lie to the east of the Dalny-Kharbin railway, at those points where the drift-deposits

of the central plain no longer mask the older rocks. The outcrops are traced up into the mountainous region where the Sungari river finds its source. So far, the work of exploring and winning the coal has been confined to the areas bordering on the railway-line. The deposits, examined and described by Baron Ferdinand von Richthofen in 1869, are still, as they were then, worked on a small scale by the Chinese, the only coal-field of more than local importance mentioned by him being that of Makiaku, probably identical with that now known as Yentai. Here the Coal-measures, possibly of Permo-Carboniferous age, overlie the Carboniferous Limestone: that limestone appears to be absent in the coal-fields situated farther north, between Mukden and Kharbin, and at Fushun, 22 miles east of Mukden. The coal of Manchuria is of very diverse character, anthracitic at Yentai, extremely bituminous at Ilu and Fushun, while at Pönhsihu coking-coal and anthracite occur side by side. Moreover, lignite-deposits have been discovered at Kwangchentsi (between Mukden and Kharbin) and at Dalai-nor, close to the Transbaikalian frontier. Ten seams are recognized in the Yentai basin, four of which only are more than 2 feet thick; and one only, No. 7, from the top, attains a thickness varying between 4½ and 6 feet. Consequently, No. 7 seam is the most actively worked of any, despite the indifferent quality of the coal. At Fushun, the two known seams strike east and west, and dip 30 degrees northward. The upper seam alone is of importance, and approaches 100 feet in thickness at the outcrop: two borings, put down to a depth of 80 feet, have proved the seam to be still of the same thickness at that depth. The outcrop extends over a length exceeding 9 miles, but this belt is cut across by two streams. The coal is highly bituminous, contains 40 per cent. of volatile matter, and yields 10 per cent. of ash. The Pönhsihu basin, containing at least five or six seams, none of which is much thicker than 3 feet, may assume importance in the future, on account of the comparative proximity (19 miles to the south) of an extremely rich deposit of magnetite. The coal, although crumbly and dirty, is suitable for coking.

The concluding chapter of the memoir is devoted to a consideration of the chief outlets in the Far East for the sale of Japanese and other coals.

L. L. B.

AURIFEROUS DEPOSITS OF TANGKOGAE, KOREA.

Das Goldvorkommen von Tangkogae in Korea. By L. BAUER. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii., pages* 69-71.

Most of the gold mined in Korea is got from placer-deposits. But few localities are known where the precious metal occurs in its original matrix, among these being the Wunsan mines in the north of the peninsula, which are systematically worked by an American company. One of the best-known localities for placer-gold is Tangkogae, 100 miles north-north-east of Seoul, between the towns of Kimsong and Hoyang, near the head-waters of the northernmost branch of the Han river. Here the thickness of the gold-bearing alluvia ranges between 10 and 56 feet; the drift-material is full of big boulders, and bedding is not easily discernible. The gold seems to be irregularly dispersed in "nests" within the entire mass; it is tolerably coarse-grained and of great purity, and nuggets weighing rather more than ½ ounce troy have been found. Matrix is seldom discovered adhering to the metal. The author gravely announces the discovery of "native lead" in these

placers; as a rule, it is true, combined with antimony, in the form of "tears," branches and flakes. In some cases the gold is encrusted over by, or involved with, this lead, the intermixture of the two metals being most intimate. Before the gold-placers were discovered, silver-ores were mined at Tangkogae, and it seems probable that these ores were smelted on the very spot where the alluvium is now washed for gold. Here we have a possible explanation of the presence of the "native lead," but the author will not have it so.

The Koreans adopt what may be called a method of ground-sluicing, but without using wooden troughs. It would not pay now to attempt to work these placers systematically, for the conditions are such as to forbid either straight hydraulicking or dredging, or any other economic method of working.

The matrix of the gold has been traced to the porphyritic dykes, which traverse the older Palæozoic rocks of the neighbourhood, and are genetically connected with a mass of biotite-granite. A milky-white to yellowish-red auriferous quartz was found, forming thin 4 inches veins on either side of one of these dykes, riddled through and through with weathered sulphidic ores.

Other placer-deposits in the neighbourhood of Tangkogae, as well as those near Morogni in Southern Korea, may be shown to have been originally derived from similar porphyry-dykes. L. L. B.

USEFUL MINERALS OF CENTRAL SIBERIA.

Die nutzbaren Lagerstätten im Gebiete der mittleren sibirischen Eisenbahnlinie. By W. Friz. *Zeitschrift für praktische Geologie*, 1905, *vol. xiii.*, *pages* 55-65, *with a map in the text.*

The district treated of by the author is the belt of country lying on either side of the great trans-continental railway, between the stations of Ob and Irkutsk, which are 1,136 miles apart.

Coal-fields.—The Suchensky basin occupies a strip some 3 miles broad, ranging generally from north-north-west to south-south-east, between the Lebedyanskoye and Suchenskoye villages, in the Government of Tomsk. The railway crosses this belt near Suchenka Station, about 155 miles east of Ob and 74 miles from Tomsk. The coal has been traced for more than 12 miles north of the railway; while south of the line the basin broadens out gradually, and eventually joins up with the Kusnetsky coal-basin, after an uninterrupted course of 93 miles. The Suchensky shales and sandstones are of Carboniferous age, and overlie conformably the Devonian rocks in company with which they have been much dislocated, in such wise that the coal-seams have generally a very steep dip. About nineteen seams have been identified (excluding those which are less than 2½ feet thick), constituting a total thickness of 105 feet of coal; but, in reality, the number of seams is much greater. Workings have as yet not been carried down to a greater depth below the surface than 200 feet, and down to that point the quality of the coal has been more or less affected by atmospheric agencies. However, the deeper one goes, the greater is the coking capacity of the mineral: that much has been ascertained. The mean of three analyses yields the following percentages: carbon, 85·26; hydrogen, 4·18; ash, 3·18; sulphur, 0·59; hygroscopic water, 1·19; coke produced, 85·24; heating

power, 7,976 calories. North of the railway alone, the amount of coal in sight, down to a depth of 328 feet, is reckoned at 100,000,000 tons. At present only three collieries are tapping the resources of this great field, and they are all situated north of the railway.

A brief description is given of the coal-deposits known to occur in four other districts; and the author then proceeds to describe the Cheremkhovo basin, near the village of that name, in the Balayansky district, about 75 miles west of the city of Irkutsk. The formations here are lacustrine clays and sandstones of Jurassic age, among which are interbedded four coal-seams of an average total thickness of 17½ feet, separated by comparatively thin partings of shale and plastic clay. The seams are only between 25 and 50 feet below the ground, and the floor of the lowermost seam is separated by but a thin layer of shale from the hummocky water-worn surface of a limestone-conglomerate, which is probably of Devonian age. This implies that deeper lying coal-seams are hardly to be looked for in that basin. The uppermost seam yields a dull-brown mineral, much fissured, resembling lignite in appearance, and crumbling away on exposure to the air. The next below yields a pitch-black lustrous coal, showing conchoidal fracture, and burning with a long flame. It contains 7·8 per cent. of hygroscopic water, and makes 54·7 per cent. of coke; while its specific gravity is 1·31, and its heating power equivalent to 6,471 calories. The coal of No. 3 seam resembles in colour and pulverulence that of the first-described seam, but in chemical composition it approximates to the mineral from No. 2 seam. The lowermost, or No. 4 seam, varying in thickness from 4½ to 7½ feet, consists of a tough, lustrous, black coal, with conchoidal fracture, suitable for transport to considerable distances. It burns with a long flame, has a specific gravity of 1·27, contains 9·52 per cent. of hygroscopic water, and its heating power is equivalent to 6,931 calories. The percentage of ash is 3·04, as compared with 13·46, 11·08 and 12·62, in Nos. 1, 2 and 3 seams respectively. The mineral of No. 4 seam is comparable with certain Westphalian coals, while that of No. 2 seam is likened to the Friedrichsthal coal of Saarbrücken. These seams give off sufficient carbon dioxide to make the working occasionally uncomfortable for the miners. The lie of the seams, the excellence of the roof, the general stratigraphical conditions, and the almost entire absence of water-feeders, combine, however, to facilitate mining operations, and the industry has developed with extreme rapidity since 1899. The output in 1902 amounted to 364,000 tons, the chief consumers being the trans-continental railway and the inhabitants of Irkutsk.

Brown Coal.—Deposits of brown coal occur all along the central portion of this railway, frequently close to the line and never very far from it. The Middle Chulym brown-coal belt alone is 435 miles in length, and in breadth it is believed to spread out considerably north of the railway; the colossal stock of fuel which it represents is as yet untouched. The Upper Chulym or Balakhtinsky basin occupies an area of at least 385 square miles, and one seam in it near the Balakhtinskoye village is known to be more than 4½ feet thick. Some seams in this basin contain, however, an inordinate proportion of ash, as much as 30 per cent. The Kubekovsky basin, on the left bank of the Yenisei, north of and near the railway-line, occupies an area of 463 square miles, wherein at least three workable seams have been proved. This basin is probably continued across the river by that of Kuskunzhsk; here an area of rather less than a square mile is said to contain more than a million tons of coal.

Iron-ores.—Turning now to the iron-ores, the author notes that the most important magnetite-deposits are: (1) Those on the left bank of the Abakan river, in the south-western portion of the Minussinsk district; this ore-belt stretches over a length of 2¼ miles, and the very pure magnetite is found to be frequently intermixed with specular iron-ore. Near the surface, it is decomposed by weathering into red and brown hæmatites. The percentage of metallic iron varies from 53·58 to 69·70, and the amount of ore in sight, down to a depth of 105 feet, is reckoned at 1,500,000 tons. (2) Those on the left bank of the Irba river, 15¼ miles above its confluence with the Tuba, in the south-eastern portion of the Minussinsk district. Here, among grey hälleflintas and augite-granites, occur stockworks of a very pure magnetite, which passes more or less completely into martite as it approaches the surface. The percentage of metallic iron in the ores ranges between 64 and 66, and there are mere traces of sulphur and phosphorus. The total quantity of ore is said to amount to 8,000,000 tons, of which 1,600,000 tons are undoubtedly in sight.

No less than ten other magnetite-deposits are briefly described, and after a reference to certain occurrences of specular iron-ore and red hæmatite, the author passes on to the brown iron-ores, which, he says, are the commonest of all in this part of Siberia. The deposits are especially numerous, in the form of small nests or thin irregular seams, in the Jurassic and Triassic coal-basins. Of similarly frequent occurrence among the coal-bearing strata are the sphærosiderites and clay-ironstones, often interbedded with the roof of the coal-seams. The author thinks that they are likely to prove of industrial importance in the near future.

Other Minerals.—Copper- and lead-ore deposits are mainly concentrated in the Minussinsk and Achinsk districts of the Yenisei province. Auriferous deposits, both placers and quartz-reefs, are found at some distance from the railway, but they occupy a belt which stretches almost without a break from the Alatáu ranges to Lake Baikal, and includes a large slice of the Yenisei basin. The author gives a long list of gold-quartz reefs, pointing out their analogy with those of Nevada county in California; they all dip very steeply, the country-rock is universally granitic, and there are two main systems of veins all but at right angles one to the other. Mention is also made of manganese-ores, or graphite-deposits (some of which have been worked out), and of salt-lakes and brine-springs. L. L. B.

KERBI-RIVER GOLD-BEARING DISTRICT, EASTERN SIBERIA.

Recherches géologiques faites en 1901 dans la Région aurifère de la Rivière Kerbi. By M. Ivanov. *Explorations géologiques dans les Régions aurifères de la Sibérie: Région aurifère de l'Amour, part iv.*, 1904, *pages* 95-122, *and* 1 *map.*

The Kerbi district is traversed by several rivers, and abuts on the west on the mountainous region of the Little Khingan. In a large measure hilly and undulating country, it slopes down gradually eastward and north-eastward into the great marshy plain, dotted with lakes, which extends on the one hand to the Amur river below Khabarovsk, and on the other to the sea of Okhotsk. The rocks are predominantly metamorphic schists of Archæan age, divisible into two groups: (1) an older series consisting of mica-schists and quartz-mica-schists, and (2) a younger series of phyllites. In the auriferous drifts numerous boulders and pebbles of massive igneous

rocks occur (diorites, diabases, porphyries, felsites, etc.), but actual outcrops of such rocks are practically non-existent. The loose-textured deposits of the great Amur plain are probably of post-Pliocene age. The metamorphic schists are traversed by quartz-veins, some of which coincide in strike and dip with the schists, while others cut across them in every conceivable direction: many of these quartz-veins are demonstrably auriferous, but prospecting for the original matrix-rock of the gold has not so far yielded any practical results, and the placer-deposits alone are worked. The richest stratum in the placers, from 14 to 28 inches thick, immediately overlies the metamorphic schists, and is really made up of decomposed schist (not water-rolled) intermingled with a blackish-grey clay. Above this comes an old river-gravel, of varying degrees of coarseness, with but little clay, also derived from the schists: the gravel-bed increases in thickness downstream, and its nether portion is rich enough in gold to be worked conjointly with the stratum first described. A thin layer of silt separates the gravel from the surface-*tundra*. The thickness of the *tundra* is extremely variable, even within the same placer-working. It depends a good deal on the slope of the valley and of the hills which flank it.

The gold occurs in tiny flakes, intermixed with granules of varying size (some rounded, others not), to which quartz is often found adhering. The tenour of gold in 100 puds (3,611 lbs.) of alluvium ranges from 40 to 150 grains troy. The tailings are rich in pyrites, which contains at times as much as 78 grains troy of gold per 100 puds. Chemical analyses of the vein-quartz show very much smaller proportions of the precious metal. An investigation now in progress is expected to prove, by means of a series of analyses, that some of the rocks which constitute the schistose formation contain gold in appreciable quantity. L. L. B.

AURIFEROUS REGION OF THE LENA, SIBERIA.

Carte géologique de la Région aurifère de la Léna : Description de la Feuille II. 6. By A. GERASIMOV. *Explorations géologiques dans les Regions aurifères de la Sibérie,* 1904, *pages* i.-viii., 1-242, *with* 21 *figures in the text and* 4 *plates.*

The area described in this memoir lies between 58° 30′ and 58° 40′ of latitude north, and between 115° 15′ and 115° 30′ of longitude east. The district is hilly, the altitudes ranging from a minimum of 2,224 feet to a maximum of 4,340 feet above sea-level: it is cut by broad and straight river-valleys, most of which trend either north and south or east and west. A detailed orographical description is given, and attention is then directed to the enormous development of alluvial deposits in the district, quite disproportionate to the size of the streams which might be supposed to have originated them. The prevalence, over hill and dale, of huge erratics of foreign granite, raises at once the suspicion that here we have an area which was formerly covered by an ice-cap. This surmise is overwhelmingly corroborated by other evidence which the author duly marshals. He sketches rapidly the hydrographic history of the district, and, noting the rarity of outcrops of solid rock, points out that such as do occur are found, without exception in the transverse valleys. The gold-mining industry has almost stripped the region of its ancient forests—remnants of which may be seen in the larch and firwoods of the upper course of the Kadali, farther

away from the more actively-worked gold-deposits. Much timber is used, not only for building-purposes and for pit-props, etc., but as fuel.

The drift-deposits occupy the river-valleys, while the hills in between are made up of a series of metamorphic schists. The drift-deposits are subdivided by the author into (1) eluvial, consisting of a fine gravel derived from the ancient rocks, sometimes intermixed with a little loam, which forms a thin layer on all the divides, wherever these have been stripped of their forest-vegetation; (2) recent alluvial, occurring only in the thalwegs of the valleys, and consisting of coarse gravels and sands, which are merely the reassorted materials of earlier drifts; and (3) ancient alluvial, among which he includes the boulder-clays, thereby implying that his use of the term "alluvial" is extremely elastic. An upper and a lower boulder-clay are distinguished, the latter being overlain by interglacial deposits. Below the lower boulder-clay come the pre-glacial grey loams, clearly stratified in their upper portion, full of rock-fragments, pyrites-crystals, and pebbles. False-bedded grey or brownish-red sands are of frequent occurrence among these pre-glacial deposits, and it is in them that the placer-gold is chiefly found. The gold, too, is often concentrated in a thin stratum known as *primazka*, immediately overlying the bed-rock and sometimes filling fissures therein. The *primazka* consists, in some places, of loam, in others of an unctuous clay, peppered with small angular fragments of the underlying rock. The auriferous bed, "properly so called," generally overlies the *primazka*, and averages from 2¼ to 5 feet in thickness, occasionally attaining a maximum of 6¼ feet. Pyrites is of frequent occurrence, as also pseudomorphs after it of limonite. The proportion of gold varies considerably from one placer to the next, and sometimes within the same placer, oscillating between 0·123 and 0·733 ounce troy per ton of gravel or loam. The so-called "terrace-placers" are comparatively rare, their very altitude having laid them open to destruction by the agencies of ice and running streams. The "valley-placers" in the older drifts are, as might be expected, much richer than those which occur among the recent alluvia along the beds of the creeks. In the last-named, the gold is in such tiny flakes that it often floats on the surface of the water, and can only be extracted from the alluvium by the aid of mercury. The terrace and older valley-placers yield gold in a much coarser state of division, very little rounded, occasionally in the shape of octahedra or deformed cubes. Nuggets weighing from 0·93 to 1·33 ounces have been obtained, and those weighing from 0·15 to 0·40 ounce are by no means uncommon.

It is explained how the glaciation of the district has conditioned the distribution of gold in the placers; and the author then passes on to consider the "solid geology"—that is, the pre-Cambrian or Cambrian metamorphic rocks which form the framework, so to speak, of the area mapped by him. They include micaceous and carbonaceous quartzites, much impregnated with pyrites; quartzo-carbonaceous schists, similarly impregnated; clearly stratified metamorphic grits, phyllites, slates, and calc-schists. On the whole, the rocks are characterized by their schistosity, their occasional fine foliation, and the invariable presence in them either of pyrites or of brown spar: they are manifestly all of them highly-metamorphosed sediments, and fall within Prof. Rosenbusch's group of the paraschists. Quartz-veins, generally snow-white, are widely disseminated among them: these veins show the most extreme variations in thickness, and are occasionally

mineralized with galena. Of course, the notion, that these quartz-veins are the original matrix of the placer-gold, is calculated to appeal to most prospectors; and certain enterprising persons have wasted much time and labour in the futile endeavour to find quartz-reefs showing more than a mere trace of gold. It seems probable that it is to the pyrites, nearly always present in the rocks and nearly always present in the placers, that we must look for the true source of the gold. Analyses of pyrites-crystals taken from the placers show them to be highly auriferous, and one may assume that it is from the decomposition of such crystals that the free gold is derived.

The occurrence of a fluor-mineral such as tourmaline, in every one of the rocks of the district, and the fact that these rocks are bounded on the south, east and west by great masses of crystalline granite of later age, suggest to the author that the granitic intrusions may have been accompanied by gaseous emanations which pervaded the cracks and fissures of the schists. In this manner, pyrites might be formed, just as well as the tourmaline; and it is noticeable that the regular cubic crystals of pyrites occur in greatest abundance along the planes of schistosity, along which the gaseous emanations in seeking an outlet would be most likely to travel. So much being granted, one is led to admit the possible existence of fluorides and sulphides of gold among these emanations: and the sulphide of gold being isomorphous with the sulphide of iron, has formed with the latter isomorphic combinations which have crystallized out in the characteristic shape of the pyrites-cube. The author claims that this is, at any rate, a plausible hypothesis of the primary origin of the gold in the district investigated by him. It would explain, moreover, the poverty of the quartz-veins, as these were probably formed at a period subsequent to the sublimation of the "auriferous gases." L. L. B.

SMEYINOGORSK ORE-DEPOSITS, SIBERIA.

Zur Kenntniss der Erzlagerstätten von Smejinogorsk (Schlangenberg) und Umgebung im Altai. By R. SPRING. *Zeitschrift für praktische Geologie,* 1905, *vol. xiii., pages* 135-141, *with a map in the text.*

The mining township of Smeyinogorsk (or Snakehill) lies among the western spurs of the Altai, in a valley some 6¼ miles broad, watered by the Korbalikha. This valley is shut in northward and southward by mountain-ridges of granite: the country between these ridges consists of a series of supposedly Lower and Middle Devonian chlorite-schists, clay-slates, and grauwackés with interbedded lenticles of limestone, the whole being intruded into by bosses and sills of quartz-porphyry. The author believes, however, that both the chlorite-schists and the granite are of pre-Devonian age. He describes and comments on the wonderful general concordance of strike of the porphyry-sills and bosses with the sedimentary rocks, touches on the occurrence of porphyritic breccias, and then remarks that the so-called "trap-dykes" (lamprophyres) represent the concluding phase of eruptivity in that portion of the Altai. These lamprophyres cut through the metalliferous ore-deposits, as well as through all the other rocks.

In the neighbourhood of the ore-deposits, the grauwackés pass into cherty slates or hornstones, and sometimes, owing to the presence of innumerable microscopic quartz-veins, take on a quartzitic appearance. This species

of contact-metamorphism is undoubtedly traceable to the hydrothermal action, which gave rise to the ore-deposits themselves. The latter may be regarded as infilling fissures in a "belt of dislocation," which is not confined to any particular geological horizon.

The author classifies the metalliferous formations of the principal reef or vein in chronological order as follows:—(1) The barytic lead-ore series, consisting predominantly of heavy-spar, galena, pyrites, and accessorily of zinc-blende and copper-pyrites; (2) the pyritic lead-ore series (exemplified in the Cherepanovsk mine), consisting predominantly of galena and zinc-blende, associated with some copper- and iron-pyrites; (3) the quartzose copper-ore series, consisting predominantly of quartz, copper- and iron-pyrites, associated with some zinc-blende; and (4) the pyritic gold-quartz series, deposited probably from thermal waters quite late in geological time.

Further, there are or were rich gossans, due to chemical decomposition of the deposits just described, by meteoric waters percolating downward from the surface. Thus a ferruginous gossan, rich in gold at the outcrop, is underlain by "the richest zone of all, the cementation-zone," which passes gradually, at a depth of about 660 feet, into the undecomposed sulphidic ores; but here the vein narrows to such an extent, that further operations were abandoned. The author concludes with a summary of the probable sequence of geological events in the area described. L. L. B.

AURIFEROUS DEPOSITS OF THE YENISEI REGION, SIBERIA.

(1) *Explorations géologiques dans les Régions aurifères de la Sibérie : Région aurifère d'Jénisséi, Livraison V.*, 1904. *By* A. K. MEISTER, N. IZHITSKY *and* L. YACHEVSKY. *Pages* 1-132, *with* 19 *figures in the text and a map ; and*

(2) *Carte géologique de la Région aurifère d'Jénisséi : Description des Feuilles K7, K8, L6, L8, L9. By* A. K. MEISTER. 1904, *pages* 1-61, 1-89, 1-36, 1-69, *and* 1-48 *respectively.*

The first-named author describes the series of dark-grey limestones, dolomites, clay-slates, red grits and limestones mapped by him along the course of the Angara, and along that of the Kamenka, a right-bank tributary of the former river. With regard to gold, he confines himself to the expression of considerable doubt as to its occurrence along the Kamenka.

The second author explored those portions of the Tis and Viatka river-basins which are comprized within sheets J 4 and J 5 of the official map. The predominant rocks here are massive crystallines and micaceous quartzites. A vein-rock, consisting of pale, coarse-grained, tourmaline-granite, was tested in the dry way for gold, but yielded none. The hornblendic and quartzose veins which traverse the crystalline rocks would also appear to be barren of gold.

The third author surveyed the extreme northern portion of the Yenisei gold-mining belt, the boundary of which is defined by the Podkamennaya Tunguzka, a tributary of the great Yenisei river. He found overlying the highly-disturbed metamorphic rocks a series of Lower Silurian sedimentaries extremely rich in fossils. The typical "Siberian traps" attain an enormous development along the Tunguzka and the Velmo, and the comparatively late age of these traps is evidenced by their cutting through not only the older sedimentaries, but also the supposedly Jurassic lignitic beds. These

traps are defined as typical diabases, and they are shown by chemical analysis to contain both gold and silver. In one of the diabase-dykes inclusions of asphalt were found. The only placer-deposits worked in this northern area are situated along the Otraikha, an affluent of the Kutukas. His memoir on the formation of ice in streams, and on the erosion of river-banks by drift-ice is abundantly illustrated, and might perhaps be of practical interest to miners in such regions as the Klondyke.

From the description of sheet K 7 of the official map the following facts may be gleaned in regard to gold. The Tatarka valley, the main valley of that area, is expected to yield a good harvest of the precious metal if dredging operations are initiated. The most favourable conditions for the formation of rich auriferous sands (placers) are present in the Podgolets and Chikil valleys; on the other hand, mining operations in the Pogromnaya and Petrishcheva valleys are not likely to yield a remunerative return.

In the area covered by sheet K 8, three series of alluvial deposits are recognized. The two older series contain sufficient gold to be of industrial importance: it is true that most of the placers have been already worked out. but some still remain untouched, and it seems probable that there are many more placers in that area, the existence of which is hardly suspected at present. Moreover, assays made in the laboratory on samples of quartz from the crystalline rocks place the discovery of gold-bearing reefs within the bounds of possibility. In describing the area covered by sheet L 6, the southern boundary of which is formed by the Angara river, the author states that the presence of gold in the siliceous phyllites and in certain quartz-veins, points to the existence of auriferous deposits outside the region to which mining operations are as yet confined. Sheet L 8 includes the lower portion of the basins of several rivers which are all tributaries of the Angara: here gold has been found in the pyritiferous dolomites, and in quartz-veins (assays from the latter yielding 0·58 ounce per ton). The area covered by sheet L 9 is geologically interesting, but there is not much hope of finding workable auriferous deposits within it.

L. L. B.

STANNIFEROUS DEPOSITS IN FRENCH INDO-CHINA.

Gisements stannifères au Laos français. By L. Gascuel. *Annales des Mines*, **1905**, *series* 10, *vol. viii., pages* 321-331, *with a map in the text.*

These remarkable deposits occur in the valley of the Nam-Patain, a small stream which runs into the Hinbun, itself a tributary of the Mekong. This valley lies in what the author terms the Middle French Laos, the country which extends along the left bank of the great river just named, between Annam and Siam, and north-east of Cambodia.

The geological structure of the intermediate neighbourhood, in so far as it can be guessed at, under a covering of barely penetrable bush and thick forest, is sufficiently simple. We have here a syncline of more or less argillaceous pale Tertiary grits, between two high serrated walls of limestone which shoot up into crags, and pinnacles, and peaks, that show no easily apparent trace of bedding. No eruptive rocks have been discovered, up to the present, in the valley or in the surrounding district; but there are quartz-veins in the grits, which undoubtedly are in some way connected with the stanniferous deposits.

On the slopes of the foot-hills are considerable quantities of limonite, .asionally manganiferous to a high degree, which appear to belong to the uppermost stratum of the grits. These are but fragmentary patches, all that has been left by erosion, of the deposit as it was originally laid down, but it is in them that the tin-ore is found, in a finely-divided state. Four such deposits are known, and there may be others: they are dispersed along the right bank of the stream, but limonite has been also observed at two points on the left bank.

The only stanniferous ore-body, that has been properly studied so far, lies a little way up stream from the village of Puntiu; but, as all the others have precisely the same external characteristics, it may perhaps be regarded as typical. The limonite has been carved up by erosion into isolated blocks immersed in sandy ore: the tin-ore occurs throughout both the blocks and the sand, in the biggest fragments as in the smallest particles. Nothing reveals its presence to the eye, except where an especially rich morsel occurs (assaying, for instance, more than 10 per cent.). The cassiterite is, indeed, in so fine a state of division that, with crushing and washing, only a very small proportion of it can be retained: most of it is carried off in the sluicings. The ore is of a red-brick colour, more or less tinged with brown: the outer surface of the bigger blocks is brown, and where manganese predominates the colour is darker still. Antimony and bismuth also occur in association with the limonite, but no sulphur. The Puntiu deposit has been worked in a nonchalant and primitive fashion by the natives, in the intervals left by the rice-sowing and the rice-harvest, by means of roughly circular shallow pits. Smelted in an equally primitive fashion, the ingots of tin are purchased by Chinese merchants at Pak Hinbun, and sent off to Bangkok. However, it is thanks to this mineral industry, such as it is, that the natives are enabled to pay regularly their taxes, even in the years of drought; as to working on a large scale, by European methods, the prospects do not seem hopeful at present. Opencast working would not be difficult, but the ores are too poor, they occur too far away from any industrial and commercial centre, and the means of access are still the reverse of easy. By the quickest route, it takes 20 to 25 days to reach the site of the deposits from Saigon, and that by a mere track. For goods, the Mekong river furnishes the only possible (but unreliable) approach. L. L. B.

MINERAL RESOURCES OF TURKEY IN ASIA.

Die nutzbaren mineralischen Bodenschätze in der kleinasiatischen Türkei. By BRUNO SIMMERSBACH. *Zeitschrift für das Berg-, Hütten- und Salinen-wesen im preussischen Staate*, 1904, *vol. lii., pages* 515-557.

The mineral belt extends for some 90 miles from the south of Asia Minor, about the latitude of the island of Rhodes, north-eastward as far as the coast of the Black sea; several important mountain-ranges lie within this belt. As the railway from Smyrna to Aidin runs through the valleys of the Guedhiz, Cayster and Mæander, more mineral-prospecting has been done in the neighbouring districts than perhaps in all the rest of the Ottoman Empire. The mineral-industry in Turkey by no means corresponds in activity with the wealth and abundance of useful minerals that are known to exist. Want of capital and the non-development of the necessary means of communication largely account for this unsatisfactory condition of affairs.

The author sketches briefly the formalities with which it is necessary to comply in order to obtain a provisional mining concession; for a concession of any considerable duration a firman from the Sultan must be obtained. In the case of chrome-iron-ore, manganese and other metalliferous mines, this holds good for 99 years; for boracite and such like deposits, the concession holds only for 60 years as a rule. An export-duty of 1 per cent. *ad valorem* is levied on minerals, and the excise-taxes on output payable to the Turkish Government vary from 5 to 20 per cent. *ad valorem*. The uncertainty of the law, the many difficulties which attend the taking-out of a mining concession, and other unfavourable circumstances, are cited as the causes which most probably check the vivifying inflow of foreign capital.

Chrome-ore.—Perhaps the most important of the useful minerals of Asia Minor is chrome-ore. At present, it is worked only in the districts bordering on the sea, chief among these being Brussa and Makri. The finest deposits, the working of which is not at present allowed by the Turkish Government, lie in the district of Denislü, in the south-west of Asia Minor: the ore which crops out there contains 56 per cent. of chromium sesquioxide. Some details are given regarding the various mines in the Brussa Kutahia, Inegöl, and Makri districts, mostly worked by British firms; and then attention is drawn to the six mines in the vicinity of the Gulf of Adalia, which belong to a French syndicate, and have been recently supplied lavishly with the most modern appliances in the way of plant, etc. The ores in these French mines yield 55½ per cent. of chromium sesquioxide. Many deposits of considerable importance occur in the vilayet of Adana, and there is little doubt that careful investigation will reveal the presence of several more chromite-deposits in Asia Minor. A complete table is given of the known mineral-concessions for chromite, both in Turkey-in-Europe and Turkey-in-Asia. So far as can be gathered from the admittedly imperfect statistics available, by far the greater portion of the exported ore goes to Great Britain.

Corundum.—Corundum occurs at numerous localities along the Mediterranean coast, and in the islands which lie off it. The most important mines are at Baltizik, Azizich, Cosbunar and Kulluk, in the neighbourhood of Smyrna. The mineral is hand-picked for export, but never washed or ground; the average percentage of pure corundum in it ranges from 40 to 57. Out of the average annual export of 17,000 to 20,000 tons, probably about one-half is absorbed by Great Britain. The author bewails, in the case of this mineral as in that of chromite, the absence of German names among the concessionaires, whereas British names are conspicuously predominant in the list of mines given by him.

Manganese-ores.—Manganese-ores are still being worked in an extremely primitive fashion, and the strenuous competition of the mines opened up by the Russians in the Caucasus has undoubtedly checked the development of manganese-mining in Asiatic Turkey. The deposits are rich and numerous, and will no doubt be worked to great advantage when the necessary capital and technical skill are forthcoming for the purpose. Meanwhile, the Turkish Government seems bent on putting what obstacles it can in the way of foreign enterprise in this matter; and such deposits as are worked by the natives hardly repay the cost and trouble involved owing, as before hinted, to the primitive methods of working which are in vogue. This statement would not, of course, apply to various important mines in the province of Smyrna which have been recently opened up under European auspices.

Copper-ores.—Perhaps the richest copper-deposits are those belonging to the Government, at Arghana, in the Armenian Taurus. The annual output amounts to about 1,500 tons, most of which is shipped at Alexandretta for conveyance to British ports. The average assay of the Arghana ore is as follows:—Copper, 30 per cent.; iron, 40; and sulphur, 30 per cent. The output from the Bulbuderé and Assarli mines in the vilayet of Smyrna, which must have been considerable in the olden times, is now insignificant. In the same vilayet there is a cupriferous mine at Cos, the situation of which (near a shipping harbour) is economically advantageous, but no work is being done there at present, nor at the Nikaria mines. About four hours' journey from the Gulf of Adalia copper-ore deposits were proved in 1902, but they are as yet unworked. The same statement applies to the deposits at Kalabaktassi in Samos. It would appear that the island of Samos furnishes a promising field for the metalliferous mining industry, but this is languishing there at present, owing to the want of sufficient capital. A great many other localities are mentioned by the author, where workable cupriferous deposits occur (some, such as those of Tokat, being of first-rate quality).

Antimony-ores.—Antimony-ores are of frequent occurrence in Asia Minor, especially in the vilayets of Brussa, Smyrna and Sivas. Want of capital and the unfavourable course of the markets have, however, affected the antimony-mining industry adversely in that part of the world. Such ore as is shipped is mostly taken by England.

Arsenic-ores.—Arsenical ores are found more especially in the vilayet of Aidin, where they occur (as at Eudemish) in pockets or nests, and always contain more or less gold, and occasionally silver. The Tshina mine works an ore, which is said to yield 35 to 42 per cent. of arsenic and 40 to 50 ounces of gold per ton.

Mercury-ores.—Mercury-ores, some of excellent quality, have been worked at various localities in the vilayet of Smyrna, but in some cases the mines have been abandoned, and in regard to others reliable information is not forthcoming.

Lead-ores.—Lead-ores are of especially frequent occurrence in the vilayet of Sivas, where they are mostly associated with antimony-ores. But few of the deposits are worked, with the exception of such mines as those of Lidjessi and Gemin-Bel, which have been taken in hand by a British company. The argentiferous lead-ores of the vilayet of Brussa are, however, the object of sufficiently active mining operations. At Balia an ore is got which yields 82 per cent. of metallic lead, and 1¼ to 4 per cent. of silver. In the vilayet of Smyrna the lead-ores are very generally associated with zinc-ores: it would appear that comparatively few of these occurrences are being worked at present.

Other Minerals.—A brief description is given of the occurrences of gold, silver and iron-ores. Passing on then to bitumen and asphalt, the author points out that the bitumen-deposits of Syria rank as the most important of all the mineral-occurrences in that province. He recites the chequered history of the Hasbaya mines, west of Mount Hermon, and alludes briefly to other important deposits, such as those of Lattikia in the Lebanon, and of the Dead sea.

Petroleum.—In the neighbourhood of Baghdad, close on the Persian frontier, one strikes a great oil-belt, which extends for 310 miles from Soerd to Mendéli in Mesopotamia. The deposits are of Tertiary age, and are doubtless of similar origin to those of the neighbouring districts of Persia

and of Baku. At the end of September, 1904, the Anatolian Railway Company obtained leave to put down borings for oil in the vilayets of Mossul and Baghdad; and if these prove successful (which is more than likely) the Company will be allowed to work the deposits for 40 years. It is expected that the export-taxes, etc., to be levied on the petroleum will more than recoup the Ottoman Government for the guarantee which they have agreed to pay on the construction of the (Baghdad?) railway. Other petroleum-occurrences are briefly mentioned, and attention is then directed to the brine-springs of El Giabul, in the vilayet of Aleppo. These are most productive, although worked in an extremely primitive fashion.

Coal.—Brown-coal deposits are fairly numerous in the vilayet of Smyrna, as well as in other provinces of Asia Minor. Of the many occurrences of ordinary coal, both in European and in Asiatic Turkey, comparatively few have been studied in detail. The provinces of Adana and Erzerum are said to be especially rich in coal, but perhaps the most important coal-field of any that is at present worked in the Ottoman Empire is that of Heraklea or Bender Eregli, close to the shore of the Black sea, extending from south-west to north-east over a length of 93 miles, while the breadth of the coal-belt often exceeds 3¾ miles. It includes numerous seams of workable coal, some of which are over 13 feet thick. The farther inland the mineral is worked, the better it seems to be. Eight proximate analyses of the coal, from as many different mines, are tabulated by the author; but as these apply to outcrop-coal, they probably do not represent the mineral at its best. That from the Coslu or Middle Group is said to be comparable in quality with Newcastle coal. A new harbour is being built at Songuldak and connected up with the coal-field by a railway-line. This will no doubt stimulate enormously the output, which for the year 1900, amounted to 255,000 tons.

In conclusion the author enumerates other mineral occurrences of industrial interest, such as the meerschaum-deposits in the vilayet of Brussa the boracite of Sultan Chaïr, the kaolin of Menemen, etc. L. L. B.

CARBONIFEROUS ROCKS IN THE FRENCH SAHARA, AFRICA.

Sur la Présence du Carbonifère moyen et supérieur dans le Sahara. By EMILE HAUG. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences,* 1905, *vol. cxl.*, *pages* 957-959.

A careful study of the material collected by Mr. F. Foureau, in the years 1894 and 1895, has led the author to assign the grits and limestones of the Erg of Iswan to the Moscovian and Uralian Series; that is, they belong to the Middle and Upper Carboniferous. Siliceous grits, with ferruginous concretions, are fairly rich in plant-remains, especially along the Wadi Assekifaf; these include *Lepidodendron*, in all stages of decortication; and one specimen recalls such Westphalian species as *L. lycopodioides* or *L. obovatum*. Prof. R. Zeiller has also determined a specimen from the same locality as being probably an *Omphalophloios*, near to *O. anglicus* of the Upper Coal-measures of Britain. It follows that the red and grey limestones which directly overlie these grits can hardly be of Dinantian (Lower Carboniferous) age, although they contain *Syringothyris*, hitherto considered to be restricted to the Dinantian. At all events, the *Productus-Cora* limestones appear to mark the summit of the Carboniferous system in the Iswan area, and the palæontological evidence unhesitatingly assigns them

to the Uralian (Upper Carboniferous). In the north of the Tassili district, the Dinantian is plainly absent, and the Lower Devonian is overlapped by the Moscovian (Middle Carboniferous). In the neighbourhood of Igli and Figig, on the other hand, the Lower Carboniferous is found conformably overlying the Upper Devonian, much as in the Belgian Ardennes; and the beds are considerably folded, whereas farther south the Devonian and Carboniferous strata are all but horizontal. The Moscovian overlap on to the Lower Devonian grits is traced at more than one locality in the Sahara, as also with great probability in Morocco, Lower Egypt, and the Sinai Peninsula.

Not a trace of coal has been found in these Carboniferous rocks of the Sahara, and now that the *Productus*-limestones of Iswan are shown to be of Middle and Upper Carboniferous age, all hope of one day finding productive Coal-measures above them has vanished. L. L. B.

IRON-ORES OF THE SHARI BASIN, FRENCH SUDAN.

Contribution à l'Étude chimique des Sols, des Eaux, et des Produits minéraux de la Région du Chari et du Lac Tchad. By ALEXANDRE HÉBERT. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1905, *vol. cxl.*, *pages* 163-165.

The only metalliferous ores met with by the Chevalier Mission, sent out by the French Government to the Shari and the Lake-Chad region, are the iron-ores which are extremely abundant in the Shari basin from the 6th to the 12th parallel [of latitude north], and are worked after a somewhat primitive fashion by the natives of those parts.

They yield a good average assay, and repay extraction by the Catalan method. Thus, the iron-ore from the Ulgu district contains 41·5 per cent. of iron sesquioxide, 0·8 per cent. of manganese, 0·5 per cent. of phosphorus, and a very trifling amount of sulphur. The iron manufactured from this by the natives contains 0·2 per cent. of carbon, from 0·1 to 0·2 of manganese, less than 0·02 of sulphur, 0·22 of phosphorus, and 1·63 of silica. The resulting slag contains 62·74 per cent. of silica and 21·59 of iron monoxide.

Natron- (or natural sodium carbonate) deposits are found in the Borku and Saharan districts, giving rise to an important trade with Borme, Bagirmi, etc., and some rock-salt beds are reported from the Rahat-Saraf river and the Wadi Demi. L. L. B.

SALINE DEPOSITS OF THE LAKE-CHAD REGION.

Les Sels de la Région du Tchad. By H. COURTET. *Comptes-rendus hebdomadaires des Séances de l'Académie des Sciences*, 1905, *vol. cxl.*, *pages* 316-318.

Lake Chad may be regarded as defining the southern boundary of a vast area of North Central Africa which abounds in deposits of alkaline salts.

At Bilma (18¼ degrees of latitude north) rock-salt has long been got, one variety having a bitter taste, and the other of a finer quality more suitable for European use. Natron is got a little to the north-east of Agades.

As to Lake Chad itself, the district abutting on its eastern and north-eastern shores is characterized by a series of lagoons which communicate with the lake in flood-time, and as they shrink to nothing in the dry season they leave great saline crusts on their floors. In the Grand Baissé

lagoon this crust consists chiefly of sodium sulphate, while in the Redema lagoon sodium chloride is the predominant salt.

Specimens obtained from the Dar Wara region show that it produces three varieties of salt: (1) the rock-salt or Toro or Turu, which is got out in little blocks 3 to 5 inches thick, and contains a good deal of epsomite or sulphate of magnesia; (2) the impure reddish rock-salt of Wadi Demi, containing nearly 50 per cent. of earthy or siliceous material; and (3) the so-called natron or *trona* ($3Na_2O.4CO_2.5H_2O$) from the same locality: this occurs as a true rock, and closely resembles the mineral got from the Natron lakes of Egypt. In default of common salt, it is often used for alimentary purposes by the natives. L. L. B.

COPPER-ORE DEPOSITS IN GERMAN SOUTH-WEST AFRICA.

Beiträge zur Geologie der Kupfererzgebiete in Deutsch Südwest-Afrika. By F. W. Voit *and* G. D. Stollreither. *Jahrbuch der Königlich-Preussischen Geologischen Landesanstalt und Bergakademie zu Berlin für das Jahr 1904, vol. xxv., pages* 384-430, *with* 10 *figures in the text and* 1 *plate.*

This memoir deals principally with the area comprized between the Swakop and Kuisib rivers, and thence eastward as far as the sixteenth meridian, a superficies comparable to that of the whole of Belgium. It does not claim to be much more than a preliminary sketch, embodying a general survey of the tectonic structure of the country. With regard to place-names the authors have retained, as far as possible, those used by the natives, preferring, for example, Otyozonyati to König Albert-Höhe, and similar meaningless substitutes beloved of German bumbledom. Their numerous collections of rock-specimens, ores, and other minerals, and the corresponding microscope-slides, have been deposited in the Museum of the Mining Academy at Freiberg in Saxony, and the results of Prof. R. Beck's microscopical investigations there are embodied in the memoir.

The comparatively waterless condition of the country traversed compels the investigator to hurry over tracts which he would otherwise study at leisure, on account of the necessity of renewing the supplies of drinking-water for both man and beast. On the other hand, the great scarcity of vegetation leaves the geological exposures open and bare to the observer. By far the greater portion of the area is formed of rocks which are extremely similar to the oldest formations exposed in British South Africa, and strata of the same age as those which contain the chief mineral wealth of the Transvaal and the Orange River Colony are conspicuous by their absence. The basement-rocks, and apparently the predominant rocks, of the German colony are crystalline schists and gneisses of every possible variety; then there is a belt wherein the granitic intrusions predominate over the gneisses; north-east of this comes another belt of crystalline schists, all but free from granitic intrusions; and north-east of this again a belt wherein the granites once more predominate. The geological map is thus of fairly simple construction, showing merely an alternation of bands trending from east-north-east to west-south-west. The crystalline schists and the granites are described in detail, and the authors regard the former as probably equivalent in age to the Proterozoic (or possibly Archæan) Malmesbury Series. The granites are directly and unconformably overlain by a sandstone of Table-mountain age. A full description is given of the contact-metamorphism locally induced in the schists by the granites, as also of

the dykes and sills of diabasic intrusives which are more especially abundant in the granitic belts. One of such dykes examined by the authors attains a thickness of 100 feet.

In the granite the only metalliferous minerals are pyrites of very sporadic occurrence, and a few flakes of molybdenite. It is in the gneisses and schists that the ores occur which formed the principal object of the authors' investigations. The comparatively few quartz-reefs which traverse the schists at a fairly low angle carry iron-pyrites, chalcopyrite, and copper-glance, containing a small percentage of gold. The discovery of bismuth and wolframite, which a former observer thought that he had found in some comparatively unimportant veins near Ussis, is not confirmed. These quartz-reefs apparently form the infilling of fold-fissures, but the ores which they carry are not in sufficient quantity to be of industrial importance. Of considerable importance, on the other hand, are the ores which occur among certain gneisses and mica-schists, in the form sometimes of impregnations, sometimes of lenticular bedded deposits, including arsenical pyrites, iron-pyrites, chalcopyrite, and copper-glance. They are chiefly associated with a band of quartzites and quartz-schists which again, when especially metalliferous, show a tendency to occur in the vicinity of hornblendic rocks. The irregular distribution of the ores, both in quantity and in kind, is characteristic of the deposits. Mining operations on any scale worthy of mention have been conducted only at three localities, namely, the Gorap mine, the Hope mine, and the Matchless mine. These are accordingly described by the authors. At the first-named mine the principal ore is a very compact intermixture of cuprite and brown hæmatite, which varies in colour from pale and dark-brown to vivid red, seamed by dendrites of blue and green copper-carbonates. The general character of the Hope mine is very similar to that of the Gorap mine: between two quartz-lenticles intercalated among the mica-schists are three 12 inches bands impregnated with sulphides and other compounds of copper. In the Matchless mine again there are three principal bands of ore, which in every characteristic are reminiscent of the so-called "fahlbands" of Norway. The ores are predominantly sulphides, oxidized nearer the surface to malachite and brown hæmatite. The occurrence of two very thick bands of hornblendic rock is a noteworthy feature.

A brief description is given of the less important deposits opened up at the Pot mine, the Ubib mine, and Hussab; and the authors describe the occurrence at Otyozonyati, which they regard as by far the most interesting in German South-west Africa, for it combines the metalliferous quartz-reefs and the fahlband-like impregnations. The locality is a high plateau, whence the headwaters of the Swakop take their rise. An extraordinarily large number of quartz-reefs here cut across the schists at high angles; they vary in thickness from 8 inches to 6½ feet, but their ascertained length hardly ever exceeds 600 feet. The gossans are not very promising: penetrating a little below the surface, however, one finds quite a wealth of ore, proved in no less than twenty different reefs. The predominant mineral is copper-glance, diminishing at first in richness with the depth and then increasing again. The occurrence of felspar and rutile in the quartz-reefs points to a genetic relationship with pegmatite-veins.

A description is given of the copper-ores of the Sinclair mine, in Great Namaqualand, 93 miles due east of Hottentot bay, and north of Lüderitz bay or Angra Pequeña. Here the gneisses and crystalline schists have been broken into by a coarse-grained dark-grey granite, which in its

turn is seamed by small dykes of a reddish-brown fine-grained aplite; with these last are associated several cupriferous quartz-veins. The actual ore-body in the Sinclair mine is a white quartz bespattered with copper-glance; the reef attains a maximum thickness of 15 feet or so, but splits out in one direction into stringers, the average thickness of which does not exceed 12 inches. The white quartz-outcrop, in places much filmed over with malachite, is traced from the sandy gravel-covered plain, up a steep mountain-wall, first branching off into stringers and then pinching out entirely. The undecomposed ore consists of pure chalcocite, distributed regularly enough in nodules varying from the size of a pea to that of a man's fist, within a stringer of the quartz-reef nearest the hanging-wall and nearest the foot-wall, thus giving a banded appearance to the whole. By far the greater part of the ore occurs in this stringer, which is 177 feet long.

All the ore-deposits described in this memoir are considered to have been the outcome of the infilling of fissures by lateral secretion, solutions carrying off the metallic particles from the country-rock and reprecipitating them in the fissures. L. L. B.

COLLAHUASI ORE-DEPOSITS, TARAPACÁ, CHILE.

Mineral de Collahuasi. By CARLOS G. AVALOS. *Boletin de la Sociedad Nacional de Minería*, 1905, *series* 3, *vol. xvi.*, *pages* 23-25.

This district lies in the eastern portion of the province of Tarapacá, on the high tableland, which northward and eastward passes into the Bolivian plateau, properly so called. Its altitude above sea-level exceeds 15,700 feet, and the climate is regarded as extremely rigorous. The journey thither, partly by rail and partly by road, either from the seaport of Iquique or from that of Antofagasta, is a matter of three days. Preparations for constructing a branch-line, between 50 and 60 miles in length, from Ollague on the Antofagasta railway to Collahuasi, are far advanced. It is calculated that freights to the sea-coast will then be exactly half of what they are at present.

So far, only exploration-work and fore-winning has been done on the mines. The country-rock is felspathic and quartziferous porphyry of varying colour: in the immediate neighbourhood of the metalliferous veins, the rock assumes a more homogeneous structure, and at the same time loses much of its toughness. Two systems of veins are recognizable—one generally striking north 40 degrees west and forming the object of the principal workings, and the other system practically perpendicular to the first. A notable enrichment is observed at the points of intersection. Thick drift-deposits (30 to 50 feet) mantle over the gentle undulations of the plateau, and mask the mineral-outcrops. The ores are cupriferous, sub-sulphates, silicates, and oxychlorides of copper predominating near the surface; while, at depths of 150 feet or more, these give place to purely sulphidic ores.

In Chile, avers the author, there are nowhere else such rich cupriferous deposits as these; and, with the advent of the railway, he forsees a monthly output of 3,000 tons of ore, containing from 25 to 30 per cent. of metallic copper. This would be nearly equivalent to one-third of the total copper-output of Chile at the present day. The labour-question does not seem likely to be productive of difficulty: most of the miners hail from Bolivia, and are inured to the rigours of the climate. L. L. B.

II.—BAROMETER, THERMOMETER, ETC., READINGS FOR THE YEAR 1904.

By M. WALTON BROWN.

The barometer, thermometer, etc., readings have been supplied by permission of the authorities of Glasgow and Kew Observatories, and give some idea of the variations of atmospheric temperature and pressure in the intervening districts in which mining operations are chiefly carried on in this country.

The barometer at Kew is 34 feet, and at Glasgow is 180 feet, above sea-level. The barometer readings at Glasgow have been reduced to 32 feet above sea-level, by the addition of 0·150 inch to each reading, and the barometrical readings at both observatories are reduced to 32° Fahr.

The statistics of fatal explosions in collieries are obtained from the annual reports of H.M. Inspectors of Mines, and are also printed upon the diagrams (Plates XXVII. and XXVIII.) recording the meteorological observations.

The times recorded are Greenwich mean time, in which midnight equals 0 or 24 hours.

TABLE I.—SUMMARY OF EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1904.

Mines-inspection Districts.	Fatal Accidents.			Non-fatal Accidents.	
	No.	Deaths.	Injured.	No.	Injured.
Cardiff	0	0	0	4	5
Durham	0	0	0	6	7
Ireland	0	0	0	0	0
Liverpool	0	0	0	1	1
Manchester	0	0	0	3	6
Midland	1	2	0	4	5
Newcastle-upon-Tyne ...	3	4	16	7	14
Scotland, East	2	2	1	21	25
Do. West	6	7	2*	41*	59*
Southern	0	0	0	4	4
Staffordshire	3	5	2	9	13
Swansea	0	0	0	26	40
Yorkshire	2	2	4	8	11
Totals	17	22	25*	134*	190*

* These figures do not agree with those recorded in *Mines and Quarries: General Report and Statistics for 1904*, 1905, part I., pages 28 and 29.

TABLE II.—LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1904.

1904.	Colliery.	Mines-inspection Districts.	Deaths	No. of Persons Injured.
Jan. 3, 22·0	Saltwells (No. 27 Pit) ...	Staffordshire ...	1	0
„ 7, 20·30	St. Helens	Newcastle-upon-Tyne	2	10
„ 19, 21·30	Calder	Yorkshire	1	2
Mar. 19, 7·10	Saltwells (No. 27 Pit) ...	Staffordshire ...	1	2
May 7, 4·40	Caledonia (fire-clay mine)	Scotland, West ...	1	0
„ 16, 22·0	Shirebrook	Midland	2	0
June 13, 9·0	Watergate	Newcastle-upon-Tyne	1	3
„ 13 or 14, unknown	Allanshaw (No. 1 Pit) ...	Scotland, West ...	2	0
„ 25, 10·30	St. John's...	Yorkshire	1	2
July 25, 6·40	Drumbow...	Scotland, East ...	1	0
Aug. 23, 9·0	Backworth	Newcastle-upon-Tyne	1	3
„ 23, 19·30	Sneyd	Staffordshire ...	3	0
Sept. 1, 22·30	Blantyre Ferme	Scotland, West ...	1	1
„ 6, 18·20	Broomhouse	Scotland, West ...	1	1
„ 26, 6·45	Rosehall (No. 14 Pit) ...	Scotland, West ...	1	0
Oct. 2, 11·0	Swinhill (No. 2 Pit) ...	Scotland, West ...	1	0
Dec. 31, 8·50	Bowhill	Scotland, East ...	1	1
			22	25

TABLE III.—LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1904.

1904.	Colliery.	Mines-inspection Districts.	No. of Persons Injured.
Jan. 4, 8·30...	Clydach Merthyr	Swansea	3
„ 5, 7·30...	Greenside	Scotland, West ...	2
„ 6, 18·30...	North Elswick	Newcastle-upon-Tyne	2
„ 7, 15·15...	St. Helens	Do. ...	5
„ 8, 18·30...	Holytown (No. 5 Pit) ...	Scotland, West ...	1
„ 12, 12·30...	Birchrock	Swansea	1
„ 15, 12·30...	Lumphinnans	Scotland, East ...	2
„ 16, 9·30...	Thornleigh (No. 1 Pit) ...	Staffordshire	3
„ 20, 8·0 ...	Blair (No. 2 Pit)	Scotland, West ...	1
„ 20, 13·0 ...	Duffryn Rhondda	Swansea	1
„ 24, 21·0 ...	Woodhall	Scotland, West ...	1
„ 26, 10·30...	Shiodin Hall	Yorkshire	1
„ 30, 8·30...	Oakwood Level (No. 31) ...	Swansea	1
Feb. 1, 23·30...	Glencraig	Scotland, East ...	1
„ 5, 6·45...	Neilston	Scotland, West ...	2
„ 12, 7·0 ...	Duxbury Park	Manchester	1
„ 12, 19·45...	Clara Vale	Newcastle-upon-Tyne	1
„ 15, 0·35...	Dale Abbey	Midland	1
„ 15, 21·30...	Newton (No. 1 Pit) ...	Scotland, West ...	1
„ 26, 8·0 ...	Bryn Navigation	Swansea	2
Mar. 1, 6·15...	Ford Hill	Yorkshire	1
„ 7, 22·0 ...	Greenfield (Threestonehill No. 7 Pit) ...	Scotland, West ...	1
„ 8, 12·45...	Twechar (No. 1 Pit) ...	Do. ...	7
„ 22, 7·45...	Cawdor	Swansea	2
„ 25, 10·0 ...	Whiteley	Midland	1
„ 25, 21·15...	Clynmil Drift	Cardiff	1
„ 28, 22·0 ...	Newton (No. 1 Pit) ...	Scotland, West ...	1
„ 29, 14·0 ...	Herdshill	Scotland, East ...	1
„ 30, 13·0 ...	Woodland (Cowley) ...	Durham	1

TABLE III.—*Continued.*

1904.		Colliery.	Mines-inspection Districts.	No. of Persons Injured.
April	9, 16·30...	Cynon	Swansea	1
„	12, 7·30...	Rigfoot	Scotland, West ...	2
„	14, 4·0 ...	Varteg Hill...	Southern	1
„	14, 21·30...	Kenmuirhill (No. 2 Pit) ...	Scotland, West ...	2
„	21, 14·30...	Howmuir	Scotland, East ...	1
„	22, 7·10 .	Struther (No. 5 Pit) ...	Scotland, West ...	1
„	22, 7·30...	Waunycoed (No. 3 Drift)...	Swansea	1
„	23, 0·30 .	Stargate Pit	Newcastle-upon-Tyne	1
„	25, 16·20...	Dumbreck (No. 2 Pit) ...	Scotland, West ...	2
„	26, 7·0 ...	Buffery Pumping Station	Staffordshire	1
„	27, 18·30...	Rosehall (No. 13 Pit) ...	Scotland, West ...	2
May	2, 22·30...	Newbattle	Scotland, East ...	1
„	6, 9·45...	New Calder...	Yorkshire	3
„	6, 10·0 ..	Thornleigh (No. 1 Pit) ...	Staffordshire	2
„	6, 14·30...	Foxley	Scotland, West ...	1
„	9, 13·0 ...	Duffryn Rhondda	Swansea	2
„	11, 15·0 ...	Dalziel and Broomside ...	Scotland, East ...	1
„	12, 4·0 ...	Abercrave	Swansea	2
„	14, 8·0 ...	Cannock Chase (Central Division)	Staffordshire	1
„	16, 6·40...	Caerlan	Cardiff...	1
„	16, 14·0 ...	Fergushill (No. 28 Pit) .	Scotland, West ...	1
„	17, 23·0 ...	Abersychan	Southern	1
„	20, 18·0 ...	Aitken	Scotland, East ..	1
„	25, 22·0 ...	Darran	Swansea	1
„	30, 11·0 .	Auchincruive (No. 1 Pit)...	Scotland, West ..	1
„	31, 10·0 ...	Meiklehill (No. 4 Pit) ...	Scotland, West ..	1
June	9, 11·0 ...	Duxbury Park	Manchester	3
„	15, 4·0 ...	Woodhorn	Newcastle-upon-Tyne	2
„	16, 15·0 ..	Himley (No. 17 Pit) ...	Staffordshire	1
„	21, 9·0 ..	Achddu	Swansea	1
„	22, 11·0 ..	Warrix (No. 1 Pit) ..	Scotland, West ..	1
„	22, 19·30..	Cynon	Swansea	1
„	27, 9·33...	Teversall	Midland	2
„	28, 9·30 ..	Newton (No. 1 Pit) ...	Scotland, West ...	1
„	30, 13·0 ...	Hattonrigg (No. 3 Pit) ...	Do. ...	1
„	30, 14·0 ...	Ystradgynlais	Swansea	7
July	6, 0·30...	Meiklehill (No. 5 Pit) ...	Scotland, West ...	2
„	6, 7·0 ...	Limefield	Scotland, East ...	1
„	8, 7·0 ...	Roman Camp	Do. ...	1
„	11, 1·0 ...	Duxbury Park	Manchester	2
„	11, 5·15...	Rose Hill	Yorkshire	1
„	11, 12·30...	Varteg Deep Black Vein ...	Southern	1
„	11, 14·30 .	Dalziel and Broomside ...	Scotland, East ...	1
„	13, 0 ..	Westburn (No. 2 Pit) ...	Scotland, West ...	1
„	13, 21·30..	Auchenharvie (No. 5 Pit)	Do. ...	2
„	21, 13·30...	Llwydcoed	Cardiff	1
„	23, 12·15...	Newburgh	Newcastle-upon-Tyne	2
„	25, 7·0 ...	Hazlehead	Yorkshire	1
„	26, 0·30...	Great Fenton (Sutherland Pit)	Staffordshire	2
„	26, 10·0 ...	Rock	Yorkshire	1
Aug.	1, 12·30...	South Skelton	Durham	1
„	3, 0 ...	Mynydd Newydd	Swansea	1
„	4, 7·30...	Blairhall	Scotland, East ...	2
„	5, 21·0 ...	Auchenharvie (No. 5 Pit)	Scotland, West ...	1
„	11, 13·40...	Auchenharvie (No. 5 Pit)	Do.	1
„	12, 13·15...	Pumpherston (No. 4) ...	Scotland, East ...	1
„	16, 13·0 ...	Duffryn Rhondda	Swansea	1
„	18, 2·15...	Pildacre	Yorkshire	1

TABLE II.—LIST OF FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1904.

1904.		Colliery.	Mines-inspection Districts.	Deaths	No. of Persons Injured.
Jan.	3, 22·0	Saltwells (No. 27 Pit) ...	Staffordshire ...	1	0
„	7, 20·30	St. Helens	Newcastle-upon-Tyne	2	10
„	19, 21·30	Calder	Yorkshire	1	2
Mar.	19, 7·10	Saltwells (No. 27 Pit) ...	Staffordshire ...	1	2
May	7, 4·40	Caledonia (fire-clay mine)	Scotland, West ...	1	0
„	16, 22·0	Shirebrook	Midland	2	0
June	13, 9·0	Watergate	Newcastle-upon-Tyne	1	3
„	13 or 14, unknown	Allanshaw (No. 1 Pit) ...	Scotland, West ...	2	0
„	25, 10·30	St. John's...	Yorkshire	1	2
July	25, 6·40	Drumbow...	Scotland, East ...	1	0
Aug.	23, 9·0	Backworth	Newcastle-upon-Tyne	1	3
„	23, 19·30	Sneyd	Staffordshire ...	3	0
Sept.	1, 22·30	Blantyre Ferme	Scotland, West ...	1	1
„	6, 18·20	Broomhouse	Scotland, West ...	1	1
„	26, 6·45	Rosehall (No. 14 Pit) ...	Scotland, West ...	1	0
Oct.	2, 11·0	Swinhill (No. 2 Pit) ...	Scotland, West ...	1	0
Dec.	31, 8·50	Bowhill	Scotland, East ...	1	1
				22	25

TABLE III.—LIST OF NON-FATAL EXPLOSIONS OF FIRE-DAMP OR COAL-DUST IN COLLIERIES IN THE SEVERAL MINES-INSPECTION DISTRICTS DURING 1904.

1904.		Colliery.	Mines-inspection Districts.	No. of Persons Injured.
Jan.	4, 8·30...	Clydach Merthyr	Swansea	3
„	5, 7·30...	Greenside	Scotland, West ...	2
„	6, 18·30...	North Elswick	Newcastle-upon-Tyne	2
„	7, 15·15..	St. Helens	Do. ..	5
„	8, 18·30...	Holytown (No. 5 Pit) ...	Scotland, West ...	1
„	12, 12·30...	Birchrock	Swansea	1
„	15, 12·30...	Lumphinnans	Scotland, East ...	2
„	16, 9·30...	Thornleigh (No. 1 Pit) ...	Staffordshire	3
„	20, 8·0 ...	Blair (No. 2 Pit)	Scotland, West ...	1
„	20, 13·0 ...	Duffryn Rhondda	Swansea	1
„	24, 21·0 ...	Woodhall	Scotland, West ...	1
„	26, 10·30...	Shiodin Hall	Yorkshire	1
„	30, 8·30...	Oakwood Level (No. 31) ...	Swansea	1
Feb.	1, 23·30...	Glencraig	Scotland, East ...	1
„	5, 6·45...	Neilston	Scotland, West ...	2
„	12, 7·0 ...	Duxbury Park	Manchester	1
„	12, 19·45...	Clara Vale	Newcastle-upon-Tyne	1
„	15, 0·35...	Dale Abbey	Midland	1
„	15, 21·30...	Newton (No. 1 Pit) ...	Scotland, West ...	1
„	26, 8·0 ...	Bryn Navigation	Swansea	2
Mar.	1, 6·15...	Ford Hill	Yorkshire	1
„	7, 22·0 ...	Greenfield (Threestonehill No. 7 Pit)	Scotland, West ...	1
„	8, 12·45...	Twechar (No. 1 Pit) ...	Do. ...	7
„	22, 7·45...	Cawdor	Swansea	2
„	25, 10·0 ...	Whiteley	Midland	1
„	25, 21·15...	Clynmil Drift	Cardiff	1
„	28, 22·0 ...	Newton (No. 1 Pit) ...	Scotland, West ...	1
„	29, 14·0 ...	Herdshill	Scotland, East ...	1
„	30, 13·0 ...	Woodland (Cowley) ...	Durham	1

TABLE III.—*Continued.*

1904.		Colliery.	Mines-inspection Districts.	No. of Persons Injured.
April	9, 16·30...	Cynon	Swansea	1
"	12, 7·30...	Rigfoot	Scotland, West ...	2
"	14, 4·0 ...	Varteg Hill...	Southern	1
"	14, 21·30...	Kenmuirhill (No. 2 Pit) ...	Scotland, West ...	2
"	21, 14·30...	Howmuir	Scotland, East ...	1
"	22, 7·10 .	Struther (No. 5 Pit) ...	Scotland, West ...	1
"	22, 7·30...	Waunycoed (No. 3 Drift)...	Swansea	1
"	23, 0·30 .	Stargate Pit	Newcastle-upon-Tyne	1
"	25, 16·20...	Dumbreck (No. 2 Pit) ...	Scotland, West ...	2
"	26, 7·0 ...	Buffery Pumping Station	Staffordshire	1
"	27, 18·30...	Rosehall (No. 13 Pit) ...	Scotland, West ...	2
May	2, 22·30...	Newbattle	Scotland, East ...	1
"	6, 9·45...	New Calder...	Yorkshire	3
"	6, 10·0 ..	Thornleigh (No. 1 Pit) ...	Staffordshire	2
"	6, 14·30...	Foxley	Scotland, West ...	1
"	9, 13·0 ...	Duffryn Rhondda	Swansea	2
"	11, 15·0 ...	Dalziel and Broomside ...	Scotland, East ...	1
"	12, 4·0 ...	Abercrave	Swansea	2
"	14, 8·0 ...	Cannock Chase (Central Division)	Staffordshire	1
"	16, 6·40...	Caerlan	Cardiff...	1
"	16, 14·0 ...	Fergushill (No. 28 Pit) .	Scotland, West ...	1
"	17, 23·0 ...	Abersychan	Southern	1
"	20, 18·0 ...	Aitken	Scotland, East ..	1
"	25, 22·0 ...	Darran	Swansea	1
"	30, 11·0 ..	Auchincruive (No. 1 Pit)...	Scotland, West ..	1
"	31, 10·0 ...	Meiklehill (No. 4 Pit) ...	Scotland, West ..	1
June	9, 11·0 ...	Duxbury Park	Manchester	3
"	15, 4·0 ...	Woodhorn	Newcastle-upon-Tyne	2
"	16, 15·0 ...	Himley (No. 17 Pit) ...	Staffordshire	1
"	21, 9·0 ..	Achddu	Swansea	1
"	22, 11·0 ...	Warrix (No. 1 Pit) ...	Scotland, West ..	1
"	22, 19·30..	Cynon	Swansea	1
"	27, 9·33...	Teversall	Midland	2
"	28, 9·30 ..	Newton (No. 1 Pit) ...	Scotland, West ...	1
"	30, 13·0 ...	Hattonrigg (No. 3 Pit) ...	Do. ...	1
"	30, 14·0 ...	Ystradgynlais	Swansea	7
July	6, 0·30...	Meiklehill (No. 5 Pit) ...	Scotland, West ...	2
"	6, 7·0 ...	Limefield	Scotland, East ...	1
"	8, 7·0 ...	Roman Camp	Do. ...	1
"	11, 1·0 ...	Duxbury Park	Manchester	2
"	11, 5·15...	Rose Hill	Yorkshire	1
"	11, 12·30...	Varteg Deep Black Vein ...	Southern	1
"	11, 14·30 .	Dalziel and Broomside ...	Scotland, East ...	1
"	13, 0 ..	Westburn (No. 2 Pit) ...	Scotland, West ...	1
"	13, 21·30..	Auchenharvie (No. 5 Pit)	Do. ...	2
"	21, 13·30...	Llwydcoed	Cardiff	1
"	23, 12·15...	Newburgh	Newcastle-upon-Tyne	2
"	25, 7·0 ...	Hazlehead	Yorkshire	1
"	26, 0·30...	Great Fenton (Sutherland Pit)	Staffordshire	2
"	26, 10·0 ...	Rock	Yorkshire	1
Aug.	1, 12·30...	South Skelton	Durham	1
"	3, 0 ...	Mynydd Newydd	Swansea	1
"	4, 7·30...	Blairhall	Scotland, East ...	2
"	5, 21·0 ...	Auchenharvie (No. 5 Pit)	Scotland, West ...	1
"	11, 13·40...	Auchenharvie (No. 5 Pit)	Do.	1
"	12, 13·15...	Pumpherston (No. 4) ...	Scotland, East ...	1
"	16, 13·0 ...	Duffryn Rhondda	Swansea	1
"	18, 2·15...	Pildacre	Yorkshire	1

TABLE III.—*Continued.*

1904.		Colliery.	Mines-inspection Districts.	No. of Persons. Injured.
Aug.	24, 23·15..	Struther (No. 5 Pit) ...	Scotland, West ..	1
Sept.	1, 19·0 ...	West Tees (Railey Fell) ..	Durham	1
"	2, 9·0 ...	Brownieside	Scotland, East ..	1
"	7, 16·0 ...	Cawdor	Swansea	1
"	9, 10·0 ...	Polmaise (No. 1 Pit) ...	Scotland, West ..	2
"	9, 16·30..	Walkinshaw (No. 2 Pit) ..	Do.	2
"	9, 18·30..	Bridgeness	Scotland, East ..	3
"	12, 16·30...	Brownlie	Do.	1
"	12, 12·15...	Cymmer	Cardiff	2
"	20, 15·0 ...	Philpstoun	Scotland, East ..	1
"	21, 13·30...	Barglachan (No. 2 Pit) ...	Scotland, West ...	1
"	26, 7·30...	Blairhall	Scotland, East ...	1
"	29, 5·15...	Watergate	Newcastle-upon-Tyne	1
"	30, 8·0 ...	Millburn	Scotland, West ..	1
Oct.	1, 7·0 ...	Mwrwg Vale (No. 2 Pit) ..	Swansea	1
"	3, 19·30...	Black Park...	Liverpool	1
"	5, 19·0 ..	Holytown (No. 13 Pit) ...	Scotland, West ..	1
"	7, 7·30...	Darran	Swansea	2
"	11, 8·15...	Rheola (No. 2 Pit)... ...	Do.	1
"	16, 21·10...	Portland (No. 4 Pit) ...	Scotland, West ..	1
"	21, 8·0 ..	Rigfoot	Do. ..	1
"	21, 21·0 ...	Achddu	Swansea	1
"	22, 21·30...	Lingdale	Durham	1
"	26, 14·0 ...	Gartshore (No. 9 Pit) ..	Scotland, West ..	1
Nov.	2, 12·30...	Benarty	Scotland, East ...	1
"	2, 13·30...	Motherwell...	Do. ..	1
"	5, 9·30...	Birchrock (Graig Merthyr)	Swansea	1
"	9, 1·0 ...	No. 9 Sirhowy	Southern	1
"	9, 7·30...	Netherton (Bridge Pit) ...	Staffordshire	1
"	12, 10·30...	Benarty	Scotland, East ...	1
"	21, 14·45...	Orbiston (No. 2 Pit) ..	Scotland, West ..	1
"	21, 20·30...	Gateside	Do.	1
"	29, 15·0 ...	Clydach Merthyr	Swansea	1
Dec.	5, 13·0 ...	Pye Hill	Midland	1
"	7, 9·0 ...	Cannock Chase (No. 3 Pit)	Staffordshire	1
"	9, 15·30...	Duffryn Rhondda	Swansea	2
"	13, 6·30...	Gartsherrie (No. 1 Pit) ..	Scotland, West ..	1
"	14, 0·10...	Mud Hall	Staffordshire	1
"	15, 13·55...	Kilton	Durham	2
"	15, 18·30...	Denby Grange	Yorkshire	2
"	20, 9·0 ...	Spa Wood	Durham	1
"	23, 7·30...	Waunycoed Pit	Swansea	1
"	23, 15·30...	Auchincruive	Scotland, West ..	3
"	23, 20·30...	Saline	Scotland, East ...	1
"	29, 7·0 ...	Mwrwg Vale (No. 2 Pit) ...	Swansea	1
"	30, 6·30...	Eglinton (No. 1 Pit) ...	Scotland, West ..	1
"	31, 7·30...	Bank (No. 1 Pit)	Do.	1
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TABLE IV.—BAROMETER, THERMOMETER, ETC., READINGS, 1904.

JANUARY, 1904.

KEW.								GLASGOW.						
	BAROMETER.				TEMPERATURE.		Direction of wind at noon.		BAROMETER.				TEMPERATURE.	
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.
1	29·870	29·917	29·945	29·989	35·6	25·9	E	1	29·892	29·912	29·899	29·914	38·1	31·6
2	29·973	29·954	29·862	29·821	44·4	31·3	ESE	2	29·848	29·779	29·623	29·507	39·4	31·3
3	29·800	29·787	29·635	29·639	46·4	43·0	SSE	3	29·501	29·300	29·365	29·469	44·3	38·1
4	29·633	29·617	29·515	29·522	44·6	32·7	S	4	29·491	29·505	29·505	29·618	40·7	35·4
5	29·677	29·887	30·032	30·185	44·0	35·7	E	5	29·755	29·919	29·999	30·091	40·0	35·2
6	30·252	30·322	30·313	30·261	38·1	31·0	SE	6	30·103	30·047	29·893	29·787	44·1	37·4
7	30·197	30·098	29·873	29·819	47·1	31·7	S	7	29·801	29·657	29·372	29·463	47·5	40·5
8	29·846	29·805	29·663	29·664	46·3	38·3	SW	8	29·506	29·513	29·496	29·521	42·1	36·9
9	29·722	29·879	30·011	30·044	42·3	35·3	W	9	29·571	29·669	29·683	29·475	39·2	35·5
10	29·890	20·794	29·850	29·937	47·3	35·3	SW	10	29·192	29·280	29·402	29·432	45·1	36·0
11	29·897	29·836	29·700	29·646	45·2	33·4	S	11	29·360	29·398	29·399	29·469	39·1	34·2
12	29·618	29·662	39·624	29·470	49·2	41·3	WSW	12	29·457	29·329	29·245	29·145	45·2	35·0
13	29·325	29·244	29·157	29·185	54·8	43·0	SW	13	28·929	28·787	28·483	28·591	45·2	40·2
14	29·016	29·039	29·047	29·375	46·9	39·1	WSW	14	28·541	28·613	28·725	29·013	45·2	36·5
15	29·534	29·678	29·687	29·691	43·3	36·2	W	15	29·185	29·285	29·301	29·441	39·2	32·7
16	29·724	29·848	29·953	30·104	39·7	33·6	NW	16	29·621	29·754	29·899	30·038	37·5	33·2
17	30·194	30·277	30·321	30·338	40·7	30·0	NW	17	30·096	30·132	30·116	30·068	42·5	33·9
18	30·269	30·218	30·224	30·268	48·3	34·1	W	18	30·068	30·139	30·180	30·242	50·1	42·0
19	30·296	30·360	30·456	30·548	49·2	32·5	NNE	19	30·314	30·396	30·418	30·420	48·5	45·2
20	30·558	30·561	30·534	30·533	35·7	30·0	E	20	30·376	30·370	30·306	30·320	46·4	43·6
21	30·453	30·448	30·492	30·595	44·2	29·8	SSW	21	30·372	30·483	30·563	30·624	44·8	37·7
22	30·663	30·708	30·668	30·672	40·7	27·6	N	22	30·617	30·582	30·534	30·528	46·1	36·9
23	30·623	30·608	30·498	30·434	34·2	27·8	N	23	30·493	30·477	30·398	30·322	45·4	42·2
24	30·313	30·285	30·184	30·171	34·1	29·9	SSE	24	30·212	30·152	30·089	30·029	43·0	39·0
25	30·150	30·167	30·106	30·060	36·6	31·6	S	25	29·948	29·900	29·796	29·776	42·4	34·5
26	30·015	30·009	29·951	29·914	47·8	34·4	S	26	29·675	29·570	29·518	29·377	46·3	39·2
27	29·825	29·782	29·717	29·657	51·0	47·2	SSW	27	29·260	29·310	29·308	29·147	49·2	42·7
28	29·662	29·679	29·675	29·768	50·9	42·2	SW	28	29·110	29·112	29·236	29·408	45·2	39·9
29	29·896	29·989	29·919	29·793	46·9	36·1	SW	29	29·555	29·609	29·431	29·094	42·2	36·2
30	29·659	29·555	29·398	29·326	45·8	42·8	S	30	29·107	29·171	29·163	29·164	45·2	39·9
31	29·314	29·239	29·191	29·293	45·0	36·3	E	31	29·156	29·249	29·308	29·375	40·9	33·8

FEBRUARY, 1904.

Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.
1	29·357	29·375	29·334	29·289	42·6	32·6	W	1	29·326	29·225	29·185	29·223	39·9	30·3
2	29·228	29·240	29·227	29·298	45·2	36·5	SE	2	29·275	29·296	29·299	29·335	39·1	33·7
3	29·259	29·137	29·070	29·274	47·7	39·7	SE	3	29·346	29·374	29·358	29·353	39·3	35·8
4	29·305	29·379	29·404	29·411	46·0	39·5	WSW	4	29·325	29·358	29·382	29·461	38·4	35·1
5	29·414	29·509	29·507	29·502	48·4	38·0	SSW	5	29·459	29·481	29·465	29·450	37·8	32·8
6	29·476	29·433	29·384	29·476	45·2	36·7	S	6	29·369	29·330	29·283	29·293	39·2	36·0
7	29·550	29·637	29·602	29·459	45·5	32·6	WSW	7	29·345	29·410	29·393	29·308	42·8	34·2
8	29·117	28·958	28·911	29·043	49·6	40·9	SW	8	29·126	28·962	28·818	28·833	39·6	34·8
9	29·164	28·944	28·628	28·728	45·0	39·3	S	9	28·818	28·785	28·712	28·741	39·2	34·1
10	28·926	28·936	28·832	28·870	47·3	37·6	SW	10	28·796	28·833	28·821	28·888	38·1	30·1
11	28·892	29·123	29·300	29·621	45·3	36·5	WNW	11	28·984	29·112	29·259	29·414	37·2	33·6
12	29·841	29·846	29·549	29·317	49·4	33·3	S	12	29·530	29·449	28·961	28·785	45·5	34·1
13	29·311	29·201	29·268	29·287	49·3	40·4	SW	13	28·569	28·482	28·548	28·656	46·2	41·9
14	29·158	29·062	28·942	29·126	47·1	38·0	WSW	14	28·586	28·632	28·853	29·040	43·4	33·3
15	29·265	29·349	29·358	29·405	42·0	31·4	W	15	29·098	29·144	29·159	29·199	39·7	31·7
16	29·492	29·520	29·308	28·950	43·6	34·1	SW	16	29·179	29·166	29·070	29·008	38·6	33·8
17	28·749	28·899	29·106	29·220	38·0	31·0	NW	17	28·971	29·007	29·093	29·270	36·7	32·2
18	29·261	29·484	29·632	29·789	41·6	31·3	N	18	29·406	29·515	29·662	29·796	41·1	32·0
19	29·913	30·055	30·045	29·927	42·0	31·7	WNW	19	29·856	29·796	29·540	29·370	45·1	28·9
20	29·763	29·802	29·794	29·800	53·0	42·0	W	20	29·416	29·485	29·505	29·546	47·7	39·2
21	29·824	29·851	29·721	29·659	53·1	47·5	WSW	21	29·599	29·500	29·156	29·207	47·8	36·0
22	29·709	29·888	30·030	30·145	48·3	38·0	NW	22	29·578	29·923	30·032	30·058	46·2	38·9
23	30·157	30·176	30·133	30·159	43·4	36·5	SE	23	30·021	30·008	29·992	30·034	43·4	36·3
24	30·141	30·194	30·184	30·218	40·9	34·3	SE	24	30·050	30·042	30·097	30·126	41·9	36·0
25	30·202	30·238	30·212	30·189	38·4	33·7	E	25	30·102	30·067	29·997	29·912	37·7	33·9
26	30·115	30·006	29·944	30·062	37·5	32·1	SSE	26	29·767	29·751	29·867	30·002	38·1	34·8
27	30·160	30·224	30·203	30·231	38·3	31·3	NNE	27	30·053	30·119	30·138	30·171	44·2	36·1
28	30·230	30·255	30·200	30·152	35·0	29·2	NNE	28	30·177	30·229	30·161	30·111	39·5	32·4
29	30·029	29·951	29·858	29·854	31·9	29·0	E	29	30·004	29·919	29·833	29·896	33·7	26·3

MARCH, 1904.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon.		Barometer.				Temperature.		Direction of wind at noon.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·855	29·917	29·940	30·021	35·8	29·3	NNE	1	29·972	30·093	30·186	30·277	37·2	29·2	NE
2	30·000	29·975	29·920	29·970	35·5	29·8	NNE	2	30·303	30·327	30·281	30·208	38·1	30·3	NE
3	30·016	30·010	29·952	29·945	37·9	32·0	NE	3	30·130	30·120	30·073	30·094	38·9	34·7	ENE
4	29·909	29·944	29·927	29·939	38·5	34·0	NE	4	30·088	30·094	30·096	30·158	37·8	33·4	ENE
5	29·914	29·927	29·875	29·858	41·1	37·5	ENE	5	30·165	30·190	30·149	30·156	39·9	33·7	ENE
6	29·796	29·770	29·723	29·716	38·9	35·9	NE	6	30·107	30·052	29·927	29·873	36·8	30·8	NE
7	29·674	29·627	29·524	29·491	44·0	38·0	E	7	29·773	29·717	29·641	29·619	36·7	31·1	ENE
8	29·523	29·613	29·651	29·769	56·1	33·6	SSW	8	29·576	29·589	29·631	29·739	40·1	35·3	ENE
9	29·813	29·895	29·898	30·033	58·0	32·1	NE	9	29·833	29·980	30·095	30·221	45·2	32·2	NNE
10	30·090	30·172	30·230	30·319	45·7	35·4	NNE	10	30·270	30·327	30·317	30·326	43·4	31·0	N
11	30·326	30·360	30·290	30·295	47·7	32·3	N	11	30·311	30·301	30·242	30·237	46·2	30·7	W
12	30·251	30·230	30·110	30·061	44·3	27·7	SE	12	30·160	30·025	29·956	29·816	43·9	32·3	W
13	29·954	29·875	29·758	29·740	47·6	32·0	WSW	13	29·613	29·540	29·494	29·552	45·7	37·4	SW
14	29·679	29·672	29·645	29·726	48·9	31·5	WSW	14	29·575	29·654	29·696	29·808	43·4	32·7	NW
15	29·841	29·957	29·969	30·053	44·7	35·3	NE	15	29·850	29·896	29·865	29·830	39·2	31·1	S
16	30·054	30·071	29·994	30·011	49·2	30·0	S	16	29·753	29·772	29·717	29·729	49·2	37·9	SW
17	29·913	29·855	29·795	29·867	47·4	31·1	ESE	17	29·685	29·709	29·737	29·803	44·8	39·1	S
18	29·921	30·022	30·017	30·086	51·9	27·0	WSW	18	29·810	29·819	29·764	29·789	45·5	38·3	S
19	30·103	30·134	30·104	30·123	53·7	40·9	WSW	19	29·815	29·770	29·728	29·792	53·3	44·1	SSW
20	30·088	30·061	30·001	29·953	54·2	47·9	SW	20	29·822	29·830	29·729	29·628	49·6	42·2	SE
21	29·878	29·901	30·008	30·187	51·2	39·5	WSW	21	29·618	29·779	29·920	29·998	46·2	40·1	WNW
22	30·270	30·264	30·152	30·136	52·5	32·3	WSW	22	29·898	29·814	29·872	30·086	49·0	39·2	WNW
23	30·204	30·300	30·297	30·326	47·2	41·0	N	23	30·236	30·346	30·355	30·399	47·6	36·3	WNW
24	30·281	30·288	30·179	30·135	48·2	38·3	NE	24	30·410	30·410	30·325	30·325	46·5	33·2	ENE
25	30·020	29·958	29·883	29·969	41·0	35·5	NE	25	30·273	30·236	30·146	30·112	40·1	32·3	E
26	29·989	30·067	30·076	30·151	44·7	36·9	NNE	26	30·073	30·096	30·085	30·144	43·8	34·8	E
27	30·180	30·266	30·247	30·290	42·6	35·8	NE	27	30·140	30·164	30·088	30·076	46·3	32·1	SSW
28	30·236	30·197	30·043	29·847	50·3	34·3	SSW	28	29·960	29·826	29·638	29·362	44·9	41·0	S
29	29·580	29·539	29·362	29·281	51·7	37·4	SW	29	29·192	29·176	29·070	29·058	44·3	35·3	W
30	29·265	29·338	29·339	29·409	46·6	31·3	WNW	30	29·070	29·123	29·144	29·304	43·3	32·2	W
31	29·477	29·643	29·613	29·515	49·2	36·9	W	31	29·446	29·426	29·274	29·198	43·7	30·2	SSE

APRIL, 1904.

1	29·612	29·759	29·853	30·003	51·0	39·6	W	1	29·184	29·277	29·430	29·620	44·5	36·6	WSW
2	30·095	30·183	30·108	29·999	53·0	38·9	SW	2	29·712	29·756	29·555	29·357	48·4	35·8	SSW
3	29·816	29·898	29·914	29·930	51·3	43·9	W	3	29·224	29·406	29·393	29·488	49·3	35·1	SW
4	29·931	30·026	30·031	30·129	51·6	39·7	W	4	29·525	29·656	29·738	29·784	47·5	35·3	W
5	30·104	30·023	29·987	29·965	53·9	43·4	W	5	29·596	29·618	29·648	29·402	50·2	42·5	W
6	29·729	29·821	29·898	29·945	56·5	41·5	WNW	6	29·134	29·542	29·635	29·562	48 8	41·0	W
7	29·856	29·780	29·842	29·959	54·8	38·8	W	7	29·383	29·485	29·641	29·731	46 1	37·9	W
8	29·942	29·955	29·921	29·955	63·1	44·3	W	8	29·740	29·673	29·556	29·582	54·4	40·3	SW
9	29·893	29·949	29·912	29·957	53·4	41·9	W	9	29·599	29·590	29·486	29·430	47·1	33·5	W
10	29·978	30·008	29·995	30·028	51·9	39·1	W	10	29·460	29·553	29·687	29·753	47·3	37·7	W
11	30·034	30·055	29·999	30·003	56·5	38·5	NW	11	29·815	29·873	29·878	29·871	49·0	40·2	WSW
12	29·919	29·814	29·636	29·526	61·7	38·9	SE	12	29·802	29·722	29·539	29·435	55·1	41·0	SE
13	29·381	29·400	29·466	29·527	56·4	50·0	SW	13	29·255	29·147	29·160	29·231	53·1	41·1	S
14	29·578	29·578	29·492	29·473	66·6	45·5	SSE	14	29·296	29·365	29·321	29·363	51·1	43·1	ESE
15	29·440	29·380	29·431	29·576	55·3	42·7	NW	15	29·347	29·315	29·279	29·341	52·8	40·8	SSE
16	29·632	29·740	29·759	29·854	60·0	39·2	WNW	16	29·391	29·539	29·647	29·765	53·2	44·1	WSW
17	29·902	29·913	29·839	29·891	61·8	39·4	SW	17	29·781	29·773	29·714	29·794	54·1	40·8	S
18	29·977	30·097	30·123	30·201	61·9	36·2	W	18	29·958	30·107	30·176	30·242	56·1	44·4	W
19	30·183	30·122	29·982	29·983	62·1	42·0	NE	19	30·232	30·208	30·095	30·082	60·9	37·1	SSE
20	29·929	29·933	29·886	29·965	62·4	41·9	N	20	30·045	30·078	30·078	30·169	53·7	40·2	NW
21	29·995	30·068	30·113	30·141	49·6	38·7	N	21	30·168	30·169	30·069	29·960	50·0	35·6	NW
22	30·072	29·957	29·746	29·651	52·0	36·3	SW	22	29·713	29·572	29·531	29·669	53·1	42·6	W
23	29·653	29·789	29·942	30·060	56·4	44·4	SSE	23	29·799	29·914	29·919	29·945	54·7	41·9	SW
24	30·079	30·139	30·055	30·001	61·0	46·4	NW	24	29·989	29·951	29·749	29·783	50·9	42·5	SW
25	30·046	30·128	30·139	30·207	53·7	39·6	NNW	25	29·907	30·003	30·040	30·045	46·4	37·9	W
26	30·187	30·182	30·098	30·085	51·0	36·9	WNW	26	29·976	29·930	29·861	29·882	49·6	38·3	WSW
27	30·044	30·092	30·069	30·099	57·0	39·7	NW	27	29·893	29·914	29·831	29·834	50·6	40·1	W
28	30·083	30·082	30·031	30·016	56·1	45·2	WSW	28	29·805	29·777	29·638	29·633	50·2	46·1	SW
29	29·960	29·961	29·935	29·927	56·2	49·7	SW	29	29·630	29·692	29·717	29·687	53·2	47·7	W
30	29·875	29·899	29·922	29·991	58·2	49·0	SW	30	29·535	29·590	29·717	29·745	51·9	43·0	W

MAY, 1904.

KEW.								GLASGOW.							
	Barometer.				Temperature.				Barometer.				Temperature.		
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.	Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	Direction of wind at noon.
1	29·998	30·001	29·911	29·866	61·0	46·8	W	1	29·701	29·667	29·494	29·418	55·1	42·9	S
2	29·640	29·708	29·651	29·845	52·6	45·2	SW	2	29·187	29·274	29·387	29·635	50·3	39·2	NW
3	29·961	30·013	29·987	29·974	55·6	40·0	W	3	29·692	29·738	29·769	29·881	50·2	40·1	NW
4	30·020	30·108	30·143	30·151	58·8	40·9	N	4	29·990	30·051	30·026	29·990	57·1	38·9	WSW
5	30·085	30·015	29·877	29·806	61·9	47·0	SSW	5	29·888	29·789	29·676	29·582	50·4	45·3	SE
6	29·708	29·682	29·574	29·549	55·5	44·9	W	6	29·526	29·532	29·591	29·639	50·2	41·1	NE
7	29·486	29·468	29·496	29·522	49·0	41·0	N	7	29·637	29·651	29·631	29·647	48·6	38·8	NNE
8	29·489	29·484	29·484	29·537	48·5	38·6	N	8	29·572	29·544	29·575	29·650	48·6	36·3	NNE
9	29·614	29·712	29·798	29·850	54·1	36·0	W	9	29·656	29·708	29·772	29·821	48·4	39·9	NNE
10	29·755	29·749	29·873	29·955	51·7	41·3	N	10	29·800	29·850	29·899	29·970	48·9	42·2	E
11	30·039	30·137	30·121	30·150	55·0	37·3	N	11	30·008	30·041	30·015	30·006	54·9	42·1	WSW
12	30·117	30·147	30·153	30·194	63·3	47·0	SW	12	29·957	29·945	29·924	29·949	53·1	40·3	SW
13	30·201	30·213	30·140	30·093	66·2	51·7	SSW	13	29·940	29·933	29·837	29·781	54·4	51·4	SSW
14	30·018	29·972	29·944	30·022	68·1	50·0	SW	14	29·721	29·574	29·725	29·759	54·5	46·1	W
15	30·046	30·067	30·021	30·073	67·2	45·9	WSW	15	29·743	29·785	29·883	29·947	54·1	44·9	W
16	30·064	30·028	29·915	29·769	71·3	42·8	S	16	29·927	29·825	29·613	29·564	66·2	42·3	SSE
17	29·694	29·774	29·843	29·942	65·3	50·2	W	17	29·580	29·608	29·603	29·612	54·0	43·2	SW
18	29·945	25·943	29·918	30·003	60·9	46·6	WSW	18	29·564	29·578	29·647	29·763	51·6	41·5	W
19	30·055	30·120	30·144	30·202	59·7	42·4	N	19	29·848	30·011	30·094	30·152	55·5	41·2	WNW
20	30·204	30·179	30·104	30·046	60·3	40·3	E	20	30·156	30·133	30·056	30·028	61·0	40·2	WSW
21	29·900	29·864	29·872	29·945	50·1	46·8	NE	21	30·001	29·982	29·944	29·970	56·8	45·8	NE
22	29·959	29·993	29·959	29·959	57·3	48·0	E	22	29·958	29·962	29·888	29·867	52·5	41·9	SE
23	29·937	29·951	29·942	29·976	64·4	50·3	W	23	29·792	29·737	29·685	29·677	52·1	45·9	S
24	29·930	29·919	29·921	29·927	55·7	51·9	SW	24	29·616	29·603	29·627	29·728	56·5	47·2	WSW
25	29·901	29·865	29·798	29·806	71·0	50·8	SE	25	29·781	29·773	29·732	29·759	60·7	40·2	S
26	29·798	29·808	29·745	29·803	73·6	48·2	SE	26	29·754	29·756	29·721	29·819	63·3	47·3	ENE
27	29·814	29·820	29·868	29·937	66·4	57·3	WSW	27	29·919	29·978	30·019	30·038	59·1	43·0	E
28	29·973	30·027	30·049	30·107	62·8	55·7	WSW	28	30·029	30·045	30·065	30·104	50·9	47·0	ENE
29	30·126	30·128	30·094	30·096	68·2	53·9	NW	29	30·103	30·115	30·061	30·107	68·8	47·3	NE
30	30·058	30·028	29·942	29·895	67·1	53·8	E	30	30·117	30·105	30·031	30·033	62·2	44·2	ENE
31	29·818	29·879	29·893	29·865	61·1	50·3	SW	31	29·967	29·886	29·80[illegible]	29·794	63·2	48·2	ENE

JUNE, 1904.

1	29·822	29·843	29·677	29·968	62·3	48·9	SW	1	29·715	29·729	29·783	29·913	54·6	49·9	W
2	30·018	30·074	30·099	30·160	57·9	50·3	N	2	29·995	30·091	30·110	30·151	65·5	45·2	W
3	30·182	30·220	30·196	30·237	63·2	49·6	NE	3	30·191	30·212	30·207	30·233	71·3	47·1	W
4	30·256	30·260	30·205	30·239	65·7	44·5	NNE	4	30·262	30·277	30·246	30·268	73·4	51·9	NE
5	30·240	30·223	30·174	30·189	69·2	48·1	NE	5	30·276	30·280	30·234	30·290	75·8	51·1	E
6	30·156	30·155	30·083	30·149	69·4	48·0	NE	6	30·304	30·313	30·288	30·291	55·6	49·1	E
7	30·128	30·123	30·050	30·082	63·5	49·3	NE	7	30·267	30·248	30·193	30·187	64·3	46·3	ENE
8	30·043	30·002	29·921	29·946	61·9	48·4	NE	8	30·159	30·143	30·088	30·112	59·1	47·0	ENE
9	29·872	29·808	29·741	29·732	58·0	48·0	NE	9	30·104	30·073	29·990	29·998	59·4	46·1	E
10	29·698	29·772	29·825	29·890	63·7	51·1	ENE	10	29·964	29·974	29·936	30·064	58·0	47·1	E
11	29·894	29·937	29·970	30·048	59·2	49·9	NE	11	30·088	30·109	30·088	30·102	64·1	47·3	E
12	30·100	30·154	30·138	30·154	64·6	51·3	NNE	12	30·110	30·097	30·033	29·995	63·8	46·1	NE
13	30·125	30·081	30·001	30·008	71·0	51·0	SSW	13	29·910	29·810	29·752	29·739	62·2	51·0	SSW
14	29·966	29.894	29·836	29·768	67·7	54·3	SSW	14	29·717	29·695	29·555	29·337	60·0	52·3	S
15	29·696	29·813	29·846	29·836	65·2	55·3	WSW	15	29·260	29·399	29·471	29·373	60·9	52·5	SW
16	29·859	29·939	29·971	30·024	68·1	55·3	WSW	16	29·351	29·457	29·513	29·617	58·2	49·4	SW
17	30·053	30·047	29·982	29·949	67·0	52·9	W	17	29·686	29·775	29·792	29·788	59·6	49·4	SW
18	29·952	30·027	30·088	30·156	67·1	49·1	NW	18	29·780	29·854	29·912	29·880	57·3	47·7	W
19	30·127	30·107	30·067	30·078	65·6	49·2	W	19	29·836	29·844	29·874	29·894	57·1	50·8	W
20	30·067	30·065	29·995	30·018	70·1	53·2	WSW	20	29·855	29·787	29·765	29·852	56·6	49·5	SW
21	30·057	30·172	30·245	30·328	63·1	49·7	NW	21	29·934	30·053	30·143	30·172	57·2	47·2	W
22	30·351	30·364	30·295	30·323	70·4	48·9	W	22	30·164	30·179	30·217	30·221	58·5	50·1	W
23	30·300	30·259	30·178	30·120	70·0	48·8	NNW	23	30·171	30·159	30·212	30·058	57·7	52·5	W
24	30·024	29·862	29·724	29·611	71·1	50·4	S	24	29·947	29·814	29·664	29·577	56·9	50·2	E
25	29·485	29·521	29·598	29·738	63·4	49·0	W	25	29·493	29·578	29·620	29·685	58·9	49·8	E
26	29·773	29·819	29·840	29·915	66·4	47·4	W	26	29·719	29·766	29·812	29·900	61·1	44·2	NW
27	29·961	30·066	30·098	30·151	68·1	48·7	NW	27	29·960	30·020	30·056	30·117	64·9	46·3	W
28	30·182	30·188	30·151	30·162	72·2	45·5	E	28	30·140	30·122	30·073	30·075	68·1	44·3	SSE
29	30·145	30·093	29·997	29·990	74·5	48·7	SE	29	30·065	30·107	29·920	29·895	72·7	47·3	S
30	29·926	29·899	29·824	29·857	78·1	53·1	SE	30	29·852	29·773	29·680	29·646	72·4	52·1	S

JULY, 1904.

KEW.								GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon.		Barometer.				Temperature.		Direction of wind at noon.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·823	29·857	29·874	29·919	69·4	54·6	SW	1	29·545	29·521	29·567	29·649	63·1	53·5	SSW
2	29·925	29·934	29·942	29·990	64·7	51·9	SW	2	29·674	22·699	29·705	29·736	62·1	49·6	SW
3	29·957	29·945	29·933	30·004	68·2	52·5	SW	3	29·708	29·719	29·736	29·823	59·1	49·0	SW
4	30·034	30·062	30·027	30·025	68·0	50·9	SW	4	29·863	29·873	29·815	29·700	56·5	49·2	SW
5	29·990	29·990	29·986	30·009	65·2	56·0	SW	5	29·701	29·789	29·843	29·858	60·1	53·1	WNW
6	30·052	30·077	30·028	30·066	75·2	52·5	W	6	29·846	29·823	29·843	29·917	59·7	52·4	SSW
7	30·094	30·149	30·159	30·180	68·3	56·0	NW	7	29·948	30·046	30·075	30·074	57·1	50·3	SW
8	30·181	30·197	30·159	30·183	79·4	58·4	SW	8	30·035	30·048	30·058	30·117	54·8	51·3	SW
9	30·203	30·214	30·149	30·172	81·3	53·7	SW	9	30·116	30·149	30·162	30·184	60·9	53·5	W
10	30·179	30·174	30·116	30·143	81·4	56·8	E	10	30·183	30·208	30·168	30·156	68·9	54·3	WSW
11	30·125	30·096	30·033	30·026	74·8	56·9	E	11	30·124	30·109	30·044	30·085	72·3	48·8	WSW
12	29·990	29·963	29·945	30·008	75·2	58·4	E	12	30·083	30·037	29·963	29·945	69·6	53·8	SE
13	30·047	30·114	30·105	30·130	77·2	57·6	WSW	13	29·904	29·886	29·929	29·950	68·5	55·1	SSW
14	30·116	30·094	30·003	30·006	79·6	56·0	S	14	29·939	29·900	29·818	29·773	62·4	54·9	S
15	29·943	29·883	29·866	29·924	81·8	60·5	S	15	29·682	29·585	29·580	29·629	61·5	55·1	S
16	29·966	30·049	30·070	30·157	79·4	60·5	SSW	16	29·765	29·906	30·009	30·107	62·6	49·6	W
17	30·181	30·172	30·116	30·192	84·3	57·0	N	17	30·162	30·198	30·204	30·252	67·6	47·3	W
18	30·230	30·242	30·188	30·192	75·1	59·0	E	18	30·283	30·279	30·201	30·171	70·9	48·1	NNW
19	30·122	30·077	29·988	29·968	75·2	57·3	E	19	30·153	30·106	30·013	30·006	66·9	51·3	ENE
20	29·931	29·903	29·888	29·930	75·1	58·9	S	20	29·996	29·935	29·911	29·900	59·5	51·1	ENE
21	29·943	29·961	29·943	29·992	78·0	55·2	W	21	29·887	29·904	29·900	29·910	64·8	53·0	E
22	30·016	30·036	30·015	30·038	74·0	55·3	SW	22	29·923	29·925	29·922	29·932	65·3	54·1	N
23	30·016	29·995	29·954	29·935	77·4	59·5	S	23	29·936	29·933	29·904	29·899	63·6	54·5	ENE
24	29·866	29·849	29·781	29·751	79·7	58·0	S	24	29·853	29·848	29·825	29·820	59·8	56·3	ENE
25	29·705	29·663	29·567	29·571	71·2	54·5	E	25	29·781	29·777	29·767	29·773	60·9	55·3	SE
26	29·581	29·608	29·616	29·669	74·7	59·3	WSW	26	29·754	29·759	29·762	29·788	58·4	53·4	ENE
27	29·676	29·743	29·805	29·876	66·3	58·8	N	27	29·797	29·832	29·857	29·891	61·5	51·0	ENE
28	29·932	30·015	30·028	30·082	72·3	58·0	WSW	28	29·918	29·972	29·965	29·979	64·4	52·8	SE
29	30·075	30·092	30·057	30·048	72·0	53·9	S	29	29·948	29·903	29·854	29·859	64·4	52·8	S
30	30·001	29·994	29·936	29·969	75·8	61·4	S	30	29·874	29·890	29·836	29·833	70·0	54·8	S
31	29·968	30·004	30·029	30·101	74·8	58·3	WSW	31	29·803	29·814	29·794	29·829	67·5	56·3	SW

AUGUST, 1904.

1	30·110	30·135	30·098	30·117	76·3	56·7	SW	1	29·876	29·937	29·934	29·949	68·1	53·8	SW
2	30·136	30·150	30·127	30·177	80·8	53·8	S	2	29·924	29·948	30·000	30·024	65·6	56·8	SW
3	30·187	30·178	30·127	30·121	85·1	54·7	S	3	30·013	30·027	30·019	29·990	68·7	60·5	S
4	30·061	29·980	29·983	29·916	86·4	61·4	S	4	29·925	29·881	29·820	29·794	71·5	59·6	S
5	29·901	29·963	29·977	30·021	74·1	61·0	SW	5	29·759	29·791	29·824	29·834	62·2	54·3	WSW
6	29·997	29·938	29·923	30·019	70·4	57·5	SW	6	29·733	29·566	29·477	29·652	62·4	55·1	E
7	30·040	30·105	30·105	30·145	70·9	55·0	W	7	29·761	29·902	29·961	30·039	64·1	53·3	W
8	30·124	30·172	30·161	30·169	72·7	56·4	N	8	30·061	30·104	30·115	30·129	64·6	50·3	W
9	30·154	30·131	30·048	30·147	70·7	52·1	WNW	9	30·083	30·039	29·989	29·973	62·2	48·7	W
10	29·998	29·999	29·927	29·909	71·0	54·3	NW	10	29·915	29·873	29·813	29·781	63·4	50·7	W
11	29·854	29·816	29·795	29·887	63·9	51·7	SW	11	29·701	29·658	29·693	29·724	54·6	49·8	N
12	29·952	30·022	30·078	30·157	68·5	49·6	W	12	29·761	29·855	29·946	30·000	62·1	45·7	W
13	30·161	30·133	30·054	29·989	71·8	48·1	SW	13	29·938	29·852	29·722	29·674	61·9	53·0	SSW
14	29·892	29·816	29·771	29·755	69·9	56·0	SW	14	29·471	29·434	29 370	29·256	63·4	56·2	SW
15	29·708	29·734	29·834	29·969	69·2	56·0	WSW	15	29·118	29·366	29·607	29·830	62·4	50·4	WNW
16	30·044	30·101	30·039	30·019	68·7	50·2	SW	16	29·919	29·959	29·951	29·907	60·4	46·8	W
17	29·935	29·793	29·634	29·660	65·7	55·0	S	17	29·816	29·725	29·614	29·667	56·7	47·6	NE
18	29·672	29·833	29·914	29·946	66·1	52·9	NW	18	29·719	29·758	29·741	29·698	61·0	48·5	WSW
19	29·915	29·924	29·933	29·993	65·0	50·0	W	19	29·710	29·832	29·887	29·941	57·7	46·8	N
20	30·010	30·052	30·036	30·071	66·2	49·4	NNW	20	29·969	30·000	30·009	30·025	61·2	42·9	NW
21	30·061	30·057	29·995	29·981	65·9	45·3	S	21	30·010	30·004	29·960	29·926	56·4	44·2	SSW
22	29·853	29·737	29·634	29·737	65·2	50·8	SE	22	29·859	29·864	29·897	30·000	57·7	49·0	ENE
23	29·893	30·043	30·071	30·093	63·2	52·6	NNE	23	30·049	30·113	30·097	30·123	59·2	48·1	NW
24	30·049	30·053	30·025	30·104	62·3	48·0	N	24	30·093	30·103	30·044	30·060	62·1	45·9	W
25	30·120	30·158	30·098	30·085	64·9	43·9	WSW	25	30·031	29·983	29·850	29·790	57·7	44·7	SW
26	29·992	29·976	29·946	30·015	69·2	52·9	WSW	26	29·703	29·679	29·698	29·782	59·7	51·5	WSW
27	30·035	30·091	30·106	30·158	70·9	52·6	NW	27	29·828	29·934	29·998	30·036	59·7	52·5	W
28	30·165	30·188	30·143	30·149	77·7	50·9	SSE	28	30·038	30·045	30·009	30·009	67·2	56·8	SSW
29	30·117	30·070	29·979	29·958	80·2	54·0	S	29	30·007	30·005	29·946	29·930	71·3	58·1	W
30	29·864	29·809	29·768	29·793	77·9	57·9	S	30	29·865	29·797	29·706	29·665	71·5	55·4	ENE
31	29·745	29·742	29·751	29·838	68·4	53·6	W	31	29·602	29·676	29·751	29·856	63·1	52·5	W

SEPTEMBER, 1904.

KEW.								GLASGOW.							
	BAROMETER.				TEMPERATURE.		Direction of wind at noon.		BAROMETER.				TEMPERATURE.		Direction of wind at noon
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	29·861	29·981	30·020	30·096	63·7	53·3	NNW	1	29·899	29·938	29·965	29·964	60·1	52·0	W
2	30·112	30·150	30·109	30·072	67·2	52·6	W	2	29·922	29·906	29·874	29·744	60·1	56·0	SW
3	29·980	29·893	29·937	30·084	65·1	49·0	SW	3	29·774	29·784	29·885	29·971	59·8	50·4	WNW
4	30·120	30·134	30·054	30·036	66·8	44·3	S	4	29·994	29·959	29·829	29·711	60·4	47·1	S
5	29·980	29·945	29·892	29·853	71·9	54·6	S	5	29·619	29·648	29·630	29·596	63·1	54·5	S
6	29·802	29·908	29·946	29·960	63·4	53·4	SW	6	29·521	29·660	29·724	29·804	63·1	53·2	SSW
7	29·950	30·019	30·063	30·157	65·1	49·7	WNW	7	29·861	29·906	29·939	29·943	59·3	50·2	W
8	30·130	30·111	29·996	29·981	59·1	48·5	S	8	29·864	29·751	29·676	29·741	57·9	49·2	SE
9	29·986	30·053	30·048	30·097	63·8	49·1	WNW	9	29·745	29·749	29 705	29·807	55·1	46·4	SW
10	30·094	30·128	30·130	30·154	62·3	45·0	NW	10	29·911	30·004	30·037	30·115	59·3	50·3	W
11	30·172	30·187	30·126	30·134	65·0	42·0	E	11	30·157	30·191	30·148	30·162	59·4	39·1	E
12	30·024	29·951	29·866	29·871	59·3	50·9	ESE	12	30·106	30·030	29·866	29·746	56·3	46·9	E
13	29·871	29·865	29·827	29·833	63·0	54·0	W	13	29·666	29·726	29·714	29·736	58·4	49·3	SW
14	29·763	29·685	29·602	29·695	58·6	47·5	ESE	14	29·700	29·693	29·689	29·784	59·1	42·4	NE
15	29·799	29·928	29 976	30·056	64·4	52·6	N	15	29·846	29·899	29·914	29·972	58·8	46·2	ENE
16	30·095	30·150	30·123	30·170	68·7	48·7	SE	16	29·987	29·998	29·993	30·044	61·2	51·0	ESE
17	30·160	30·192	30·183	30·138	69·1	52·4	SSE	17	30·075	30·110	30·112	30·151	65·7	57·4	SSE
18	30·256	30·286	30·247	30·251	64·0	48·4	ENE	18	30·170	30·196	30·179	30·208	65·1	50·3	SE
19	30·234	30·242	30·178	30·206	64·0	49·3	E	19	30·215	30·239	30·190	30·196	64·4	46·7	SE
20	30·212	30·239	30·186	30·196	61·0	45·3	E	20	30·203	30·244	30·196	30·236	61·9	45·5	SE
21	30·172	30·157	30·091	30·068	59·0	42·9	E	21	30·236	30·258	30·184	30·208	60·3	39·3	NE
22	30·023	30·034	30·011	30·019	57·4	50·0	NE	22	30·214	30·243	30·244	30·293	57·1	44·9	ENE
23	30·043	30·112	30·094	30·105	59·6	51·5	NE	23	30·296	30·328	30·302	30·311	58·5	48·3	E
24	30·024	29·990	29·911	29·875	59·4	48·1	N	24	30·279	30·242	30·143	30·067	52·7	48·1	NE
25	29·806	29·794	29·764	29·840	58·6	44·9	NE	25	29·956	29·874	29·767	29·742	53·4	47·1	NE
26	29·885	29·963	29·961	30·015	62·3	38·0	SW	26	29·729	29·780	29·799	29·858	55·5	42·5	SW
27	29·996	30·034	29·995	30·047	61·9	38·2	SW	27	29·867	29·921	29·948	30·006	58·1	43·3	SW
28	30·054	30·105	30·086	30·135	60·1	41·0	SE	28	30·026	30·078	30·071	30·116	59·3	41·3	ESE
29	30·126	30·158	30·103	30·122	62·2	43·0	N	29	30·094	30·091	29·974	29·909	61·1	40·0	SW
30	30·079	30·042	29·942	29·880	58·9	41·4	SSW	30	29·729	29·599	29·592	29·598	56·8	50·6	SW

OCTOBER, 1904.

1	29·740	29·707	29·826	29·947	61·0	44·7	N	1	29·540	29·561	29·616	29·676	54·1	46·3	SW
2	29·948	29·995	29·981	30·072	54·9	39·7	WNW	2	29·709	29·832	29·937	30·050	52·7	43·3	WNW
3	30·096	30·223	30·254	30·319	60·1	47·1	NE	3	30·090	30·177	30·191	30·186	55·1	42·3	WSW
4	30·264	30·236	30·106	30·059	62·4	40·3	SW	4	30·056	29·931	29·819	29·804	55·1	48·1	SW
5	30·015	29·968	29·790	29·516	59·1	50·6	W	5	29·785	29·746	29·309	28·900	54·5	48·9	SW
6	29·452	29·595	29·676	29·665	58·1	48·2	WNW	6	29·117	29·410	29·506	29·548	56·9	47·0	W
7	29·487	29·522	29·718	29·904	51·8	41·7	NNW	7	29·585	29·675	29·697	29·791	50·6	40·9	W
8	29·953	20·008	30·064	30·186	51·3	39·1	NW	8	29·806	29·970	30·049	30·104	48·1	39·0	NW
9	30·234	30·375	30·235	30·242	54·7	34·6	W	9	30·040	29·960	29·921	30·034	52·6	40·2	SW
10	30·217	30·241	30·221	30·240	58·0	47·1	SW	10	30·075	30·083	30·052	30·028	53·1	38·2	SW
11	30·223	30·227	30·165	30·167	59·3	50·7	SW	11	29·944	30·018	29·987	30·079	54·8	47·3	SW
12	30·160	30·252	30·306	30·442	57·6	40·4	NNE	12	30·198	30·313	30·349	30·410	52·0	38·9	W
13	30·451	30·478	30·364	30·335	55·8	35·2	E	13	30·399	30·395	30·264	30·238	51·5	34·9	S
14	30·233	30·180	30·068	30·053	55·1	37·5	E	14	30·179	30·179	30·086	30·052	52·6	46·3	SSE
15	30·010	30·013	29·938	29·952	54·1	32·3	SE	15	29·977	29·942	29·859	29·833	50·1	42·8	SSW
16	29·944	29·985	29·976	29·968	54·4	39·9	ESE	16	29·806	29·768	29·652	29·491	50·7	42·2	SW
17	29·855	29·802	29·877	20·987	60·0	51·0	SW	17	29·266	29·390	29·613	29·695	54·6	47·3	W
18	30·003	30·138	30·228	30·354	65·9	53·0	W	18	29·798	29·975	30·086	30·192	55·3	48·3	W
19	30·399	30·441	30·430	30·403	57·9	50·3	S	19	30·271	30·343	30·322	30·305	57·4	49·4	W
20	30·353	30·300	30·180	30·111	64·9	52·3	E	20	30·223	30·188	30·088	30·021	57·3	51·1	SSW
21	30·018	29·983	29·897	29·829	58·6	53·4	WSW	21	29·897	29·793	29·631	29·589	58·1	53·1	S
22	29·726	29·779	29·774	29·800	58·7	45·1	W	22	29·546	29·577	29·587	29·610	53·9	45·1	SW
23	29·766	29·778	29·776	29·847	59·8	47·4	SSE	23	29·633	29·676	29·680	29·765	52·9	47·4	SSE
24	29·899	30·005	30·020	30·104	58·0	51·7	NE	24	29 826	29·892	29·923	30·010	52·3	41·6	WSW
25	30·184	30·246	30·216	30·226	54·8	41·0	NW	25	30·046	30·077	30·019	30·009	52·1	44·9	W
26	30·171	30·208	30·186	30·231	55·6	43·9	NW	26	30·082	30·085	30·140	30·181	52·9	48·3	WSW
27	30·244	30·272	30·182	30·186	50·3	37·8	NW	27	30·157	30·160	30·083	30·044	50·3	43·4	SW
28	30·133	30·154	30·147	30·216	57·1	45·1	SE	28	29·988	30·056	30·111	30·236	54·1	45·0	WSW
29	30·236	30·262	30·216	30·162	55·6	41·3	E	29	30·319	30·398	30·360	30·320	52·1	49·0	ENE
30	30·097	30·112	30·082	30·110	51·0	46·3	ENE	30	30·242	30·256	30·201	30·224	50·4	41·2	E
31	30·079	30·108	30·107	30·159	49·2	46·3	NE	31	30·217	30·244	30·234	30·279	48·4	42·9	ENE

NOVEMBER, 1904.

	KEW.							GLASGOW.							
	Barometer.				Temperature.		Direction of wind at noon.		Barometer.				Temperature.		Direction of wind at noon.
Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.		Date.	4 A.M.	10 A.M.	4 P.M.	10 P.M.	Max	Min.	
1	30·180	30·257	30·284	30·380	51·1	46·8	NE	1	30·289	30·353	30·377	30·409	48·4	45·7	NE
2	30·408	30·470	30·457	30·455	52·0	47·0	NE	2	30·407	30·359	30·253	30·133	49·6	45·9	SW
3	30·377	30·351	30·275	30·278	56·0	46·0	WSW	3	30·045	30·088	30·069	30·062	55·1	49·1	W
4	30·258	30·258	30·186	30·158	52·3	42·4	WSW	4	—	30·078	30·016	29·970	53·9	49·8	W
5	30·076	30·073	30·009	30·018	55·4	47·3	WNW	5	29·873	29·813	29·806	29·814	51·6	44·3	SW
6	29.994	30·026	30·008	29·994	53·6	43·2	W	6	29·811	29·852	29·863	29·852	45·4	37·9	W
7	29·862	29·693	29·453	29·541	51·4	43·4	SSW	7	29·708	29·563	29·501	29·487	40·5	36·2	NE
8	29·739	29·883	29·907	29·819	50·0	41·7	W	8	29·527	29·603	29·521	29·260	51·9	36·6	WNW
9	29·649	29·563	29·534	29·559	59·6	50·0	W	9	29·159	29·158	29·229	29·544	52·9	41·2	W
10	29·813	30·014	30·070	30·007	56·1	46·8	NNW	10	29·831	29·983	29·954	29·850	41·8	33·9	E
11	29·859	29·922	29·917	29·972	58·9	47·0	W	11	29·700	29·694	29·703	29·774	45·3	37·1	NNW
12	30·066	30·211	30·262	30·351	54·5	35·4	W	12	29·833	29·958	30·083	30·175	50·3	43·4	WSW
13	30·384	30·431	30·421	30·479	52·1	31·7	WNW	13	30·191	30·221	30·243	30·302	54·1	43·8	SW
14	30·509	30·572	30·554	30·589	46·8	31·6	S	14	30·343	30·404	30·413	30·373	52·5	50·3	SSW
15	30·549	30·543	30·438	30·435	48·1	29·6	SE	15	30·310	30·256	30·193	30·279	52·4	42·0	SW
16	30·415	30·433	30·397	30·439	51·1	33·4	N	16	30·358	30·401	30·384	30·376	48·7	44·1	W
17	30·458	30·500	30·472	30·456	45·0	37·8	NNE	17	30·359	30·345	30·292	30·265	51·3	44·9	SW
18	30·407	30·394	30·322	30·256	42·8	35·6	W	18	30·226	30·208	30·094	29·975	53·4	48·9	W
19	30·174	30·153	30·099	30·118	51·1	41·6	WSW	19	29·875	29·912	29·865	29·854	49·4	39·2	W
20	30·079	30·061	30·017	30·034	46·6	35·9	WNW	20	29·820	29·830	29·807	29·819	41·3	31·3	W
21	29·980	29·918	29·704	29·494	43·2	32·8	SW	21	29·720	29·642	29·526	29·505	31·9	26·1	SW
22	29·429	39·359	29·435	29·506	37·5	31·7	WNW	22	29·544	29·568	29·566	29·520	37·0	26·2	N
23	29·493	29·514	29·514	29·574	38·0	28·9	W	23	29·445	29·519	29·551	29·621	38·5	30·1	N
24	29·621	29·698	29·685	29·727	33·6	26·1	NW	24	29·704	29·801	29·816	29·863	39·6	34·6	N
25	29·744	29·775	29·762	29·804	36·1	28·4	NW	25	29·829	29·777	29·718	29·798	37·4	31·4	WNW
26	29·833	29·953	29·968	29·990	32·5	24·1	NW	26	29·897	30·000	29·984	29·961	35·2	23·4	E
27	29·958	29·919	29·833	29·798	35·1	25·1	NW	27	29·885	29·823	29·733	29·699	40·8	30·1	E
28	29·748	29·768	29·812	29·879	38·0	30·7	W	28	29·698	29·779	29·831	29·857	38·1	29·6	SW
29	29·944	30·027	30·047	30·089	41·1	29·4	SW	29	29·889	29·901	29·905	29·899	47·4	31·4	SW
30	30·054	30·032	29·967	29·965	47·8	35·3	W	30	29·831	29·776	29·735	29·710	49·5	43·4	W

DECEMBER, 1904.

1	29·963	30·004	29·948	29·922	49·4	42·5	W	1	29·663	29·665	29·635	29·618	49·3	42·4	WSW
2	29·841	29·801	29·723	29·704	49·4	41·6	N	2	29·564	29·557	29·504	29·482	44·1	40·3	SW
3	29·662	29·714	29·713	29·767	47·0	41·1	W	3	—	29·455	29·461	29·410	45·4	41·2	SW
4	29·778	29·760	29·660	29·557	53·3	42·5	SW	4	—	—	29·077	28·944	54·5	44·9	SSE
5	29·532	29·632	29·572	29·603	54·0	43·1	SW	5	28·947	29·133	29·234	29·277	49·6	40·6	WSW
6	29·577	29·428	29·129	29·360	47·7	39·0	WSW	6	29·234	29·144	29·067	29·099	41·3	35·1	SE
7	29·328	29·296	29·339	29·433	41·3	36·8	WSW	7	29·152	29·145	29·185	29·346	38·6	30·3	WNW
8	29·445	29·622	29·776	29·817	39·7	27·6	NW	8	29·530	29·669	29·666	29·641	36·4	29·9	W
9	29·645	29·464	29·300	29·280	45·0	27·0	SE	9	29·546	29·477	29·440	29·458	35·7	30·5	E
10	29·249	29·288	29·371	29·534	44·6	37·8	SSE	10	29·453	29·516	29·562	29·626	37·1	29·9	N
11	29·628	29·673	29·560	29·296	44·3	31·4	W	11	29·578	29·482	29·372	28·984	36·3	21·9	NE
12	28·978	28·936	28·950	29·136	46·5	37·3	SW	12	28·808	28·838	28·972	29·256	39·6	32·6	NW
13	29·296	29·519	29·653	29·710	43·2	33·8	NW	13	29·496	29·631	29·643	29·636	39·8	31·4	NW
14	29·633	29·513	29·402	29·532	43·9	31·9	SSE	14	29·326	29·192	29·195	29·241	43·1	34·3	SW
15	29·600	29·694	29·760	29·831	45·3	36·2	SW	15	29·284	29·428	29·515	29·505	44·1	39·8	SW
16	29·816	29·879	29·929	30·039	54·4	44·3	SW	16	29·359	29·366	29·394	29·555	54·1	41·5	SSW
17	30 101	30·177	30·221	30·216	55·0	50·1	SW	17	29·610	29·582	29·720	29·848	54·1	46·2	SW
18	30·243	30·299	30·451	30 566	53·6	32·9	N	18	29·967	30·166	30·329	30·441	47·2	40·2	W
19	30·577	30·612	30·556	30·547	40·0	31·2	N	19	30·482	30·500	30·461	30·456	41·3	35·1	SW
20	30·512	30·520	30·464	30·454	39·6	33·7	ESE	20	30·418	30·402	30·351	30·346	43·4	37·1	SSW
21	30·436	30·447	30·408	30·418	34·0	29·3	SE	21	30·314	30·317	30·301	30·317	43·0	37·3	SSW
22	30·399	30·407	30·371	30·365	31·4	26·6	SE	22	30·306	30·322	30·295	30·294	42·8	40·2	SW
23	30·324	30·320	30·274	30·292	34·7	28·3	SE	23	30·269	30·275	30·259	30·243	42·6	39·1	WSW
24	30·232	30·203	30·122	30·086	34·9	29·9	N	24	30·177	30·139	30·030	30·023	42·9	36·2	SW
25	30·040	30·043	29·988	29·986	41·2	32·2	NE	25	30·001	29·987	29·959	29·968	40·0	34·1	S
26	29·966	29·963	29·962	30·024	37·9	34·1	NE	26	29·960	29·967	29·969	30·020	35·8	29·2	E
27	30·119	30·250	30·304	30·347	39·7	32·6	NE	27	30·078	30·141	30·162	30·185	40·1	29·9	ENE
28	30·380	30·412	30·427	30·440	46·4	33·6	W	28	30·197	30·226	30·197	30·066	47·8	38·1	SW
29	30·381	30·390	30·322	30·261	54·6	46·4	SW	29	29·967	30·015	29·885	29·709	53·9	47·3	W
30	30·002	29·826	29·973	30·081	54·0	43·1	NW	30	29·425	29·783	29·923	30·094	51·3	41·4	NW
31	30·167	30·269	30·307	30·403	44·9	35·3	N	31	30·196	30·278	30·323	30·413	42·9	36·1	W

CONGRÈS INTERNATIONAL DES MINES, DE LA MÉTALLURGIE, DE LA MÉCANIQUE ET DE LA GÉOLOGIE APPLIQUÉES.

HELD AT LIÉGE, JUNE 25TH TO JULY 1ST, 1905.

The following papers were read and discussed in the several sections:—

I.—SECTION DES MINES.

"Pneumatogène: nouveau système d'appareils de sauvetage pour les milieux irrespirables." By Messrs. M. Bamberger, F. Böck and F. Wanz.
"Sur les mouvements du sol consécutifs aux travaux houillers." By Messrs. Achille Bertiaux and Arthur Pépin.
"Sur l'inflammation des explosifs." By Mr. C. E. Bichel.
"Les creusements de puits en Allemagne en terrains aquifères." By Mr. Maurice Bodart.
"Utilisation des vapeurs d'échappement par accumulateurs et turbines à basse pression." By Messrs. Paul Jos. Alexis Chaleil and Auguste Rateau.
"L'organisation actuelle de la grisoumétrie dans les houillères françaises." By Mr. Gabriel Chesneau.
"Recherches sur l'action des conducteurs électriques incandescents et de l'étincelle électrique dans les mélanges grisouteux." By Messrs. Henry Couriot and J. Meunier.
"L'électricité appliquée à l'extraction." By Mr. Léon Creplet.
"L'expérimentation des explosifs de sûreté." By Dr. J. Daniel.
"Essai d'un cadre pour l'unification de la statistique des accidents des mines." By Mr. A. de Keppen.
"Unification des statistiques minières officielles." By Mr. Louis Dejardin.
"Méthode d'exploitation employée au siège du Quesnoy." By Mr. Adolphe Demeure.
"Recherches expérimentales sur la résistance et l'élasticité des câbles d'extraction." By Mr. Lucien Denoël.
"Considérations pratiques sur les installations de lavage des charbons en usage en Belgique." By Mr. Émile Discry.
"Détermination du module d'élasticité des câbles en fils de fer ou d'acier, par le calcul et par l'expérience." By Mr. Jules Divis.
"Les procédés d'exécution de la galerie de Gardanne à la mer de la Société Nouvelle de Charbonnages des Bouches-du-Rhône." By Mr. Henri Domage.
"Fonçage des puits en terrains aquifères." By Mr. Emmanuel Duvivier.
"Nouvel appareil de forage pour puits de mines de la Deutsche Tiefbohr-Aktiengesellschaft, à Nordhausen, Harz." By Mr. Ed. Frieh.
"Appareil respiratoire et boîte de secours pour mineurs." By Dr. Ernest Guglielminetti.
"Les machines d'extraction électriques." By Mr. Paul Habets.

"Le matériel des installations électriques souterraines." By Mr. Armand Halleux.

"Trois années d'expériences sur les machines d'extraction." By Mr. René A. Henry.

"Les installations électriques des charbonnages du Hasard." By Mr. René A. Henry.

"Le lavage des charbons: commande par bielles hydrauliques de divers appareils de préparation mécanique." By Mr. René A. Henry.

"L'état actuel et l'avenir du remblayage hydraulique." By Mr. Fritz Jüngst.

"Du règlement des différends entre les sociétés minières et les propriétaires de maisons endommagées en Allemagne." By Mr. Ernst Kolbe.

"Application du procédé de remblayage par l'eau à l'exploitation d'une veine d'un mètre, à la fosse No. 1 de la Société des Mines de Lens." By Mr. Henri Lafitte.

"Conditions à remplir pour le matériel électrique des mines." By Mr. Noël Lapostolest.

"Organisation du sauvetage." By Mr. G. A. Meyer.

"Description abrégée des objets exposés par la Société Minière Hibernia à l'Exposition Universelle de Liége de 1905." By Mr. G. A. Meyer.

"Cimentation des terrains aquifères en vue du creusement des puits." By Mr. Henri Portier.

"Pompes centrifuges pour hautes pressions mues par turbines à vapeur." By Mr. Auguste Rateau.

"La machine d'extraction électrique." By Mr. Henri Rouard.

"Le creusement des puits en morts-terrains à grande profondeur." By Mr. Georges Rouy.

"Les machines d'épuisement modernes." By Mr. F. Schulte.

"Pompes centrifuges de Laval à haute pression, à disques simples et à disques multiples." By Mr. Kasimir Sosnowski.

"Les lampes de sûreté et les explosifs au siège d'expériences de Frameries." By Messrs. Simon Stassart and Victor Watteyne.

"Les appareils de sauvetage." By Mr. — Suess.

"Procédés de fonçage employés pour la traversée des terrains aquifères au puits 'Maximilian' près de Hamm, Westphalie." By Mr. Eugène Tomson.

"Note sur l'emploi de la vapeur surchauffée." By Mr. Paul Weiss.

"Les dégradations constatées à Paris et dans le département de la Seine résultant des anciennes exploitations de carrières, avec une description des travaux et méthodes de consolidation en usage." By Messrs. Paul Weiss and — Wickersheimer.

"Bélier perforateur hydraulique." By Mr. Waclaw Wolski.

"Pompes centrifuges, système Sulzer, à haute pression, considérées au point de vue de leur résultat pratique." By Mr. Paul H. Ziegler.

II.—Section de Métallurgie.

"Exposé et critique des nouveaux procédés de fabrication de l'acier sur sôle." By Mr. P. Acker.

"Épuration des gaz de hauts-fourneaux." By Mr. Émile Bian.

"Changement de structure produit par le laminage et le recuit." By Mr. William Campbell.

"L'électricité appliquée aux trains de laminoirs." By Mr. Léon Creplet.

"Moyens d'empêcher la retassure des lingots d'acier." By Mr. R. M. Daelen.
"Désulfuration et déphosphoration des fontes." By Mr. Puissant d'Agimont.
"Ciments de laitier: perfectionnement de leur fabrication et développement de leur emploi." By Mr. Cécil de Schwarz.
"Utilisation du gaz disponible des hauts-fourneaux." By Mr. Victor Defays.
"La dessication de l'air insufflé aux hauts-fourneaux." By Mr. Victor Defays.
"De l'influence du titane sur les fontes et aciers." By Mr. Pierre Delville.
"La dessication du vent." By Mr. Edouard Edm. Divary.
"Note sur un ventilateur épurateur centrifuge avec cyclone séparateur, breveté S.G.D.G., système E. Farcot fils, pour vapeurs et gaz chargés de poussières solides et liquides." By Mr. Emmanuel Farcot.
"Emploi de l'acétylène pour la soudure autogène des métaux." By Mr. Edmond Fouché.
"La fabrication électrique de l'acier." By Mr. Gustave Gin.
"Les aciers spéciaux." By Mr. Léon Guillet.
"Constitution des alliages du cuivre." By Mr. Léon Guillet.
"Effet de la température de l'air liquide sur les propriétés mécaniques et autres du fer et de ses alliages." By Mr. Robert A. Hadfield.
"Utilisation des charbons pauvres en matières agglutinantes pour la fabrication du coke." By Mr. Henri Hennebutte.
"Procédé de chauffe et de travail des métaux par l'électricité." By Mr. Paul Hoho.
"Utilisation des gaz de haut-fourneau comme force motrice des laminoirs." By Mr. Carl Ilgner.
"Le coupage des métaux par l'oxygène." By Mr. Félix Jottrand.
"Les nouveaux procédés de soudure." By Mr. Félix Jottrand.
"Appareils de chargement des fours Martins." By Mr. David Kainscop.
"Sur la technique de la métallographie microscopique." By Mr. Henry Le Châtelier.
"Examen métallographique des fers, aciers et fontes." By Mr. Henry Le Châtelier.
"Appareil d'essai de dureté des cokes métallurgiques." By Mr. Émile Lecocq.
"Influence de la dessication du vent sur la marche du haut-fourneau." By Mr. Arthur Lodin.
"La double trempe des grosses pièces de machines en acier forgé." By Mr. Alfred Pierrard.
"Le four électrique en métallurgie." By Mr. Robert Pitaval.
"Fonction de l'air chaud dans le haut-fourneau." By Mr. Joseph W. Richards.
"Le four Cermak-Spirek pour le grillage et la calcination des minerais: type 1901." By Mr. Vincenzo Spirek.
"Appareil de chargement sans fumée." By Mr. Vincenzo Spirek.
"Amélioration de la qualité des gaz de four, spécialement des gaz de hauts-fourneaux, par régénération et séparation." By Mr. Joseph Von Ehrenwerth.
"Extraction de l'argent du sulfure d'argent dans le procédé de l'amalgamation." By Mr. Tosio Watanake.
"Emploi du laitier de haut-fourneau à la fabrication du mortier hydraulique." By Dr. Herman Wedding.

III.—SECTION DE MÉCANIQUE.

" La turbine à gaz: système Armengaud-Lemale." By Mr. René Armengaud.
" Bases de calcul des turbines à vapeur." By Mr. Donat Banki.
" Mémoire sur les turbines à gaz." By Mr. Rudolph Barcow.
" Rapport sur la marche en parallèle des alternateurs." By Mr. Paul Boucherot.
" Considérations sur le rendement théorique des moteurs à explosion et à compression préalable." By Mr. J. Boulvin.
" Note sur le calcul des surchauffeurs de vapeur." By Mr. J. Boulvin.
" Détermination du rendement volumétrique et du rendement dynamique d'un compresseur d'air." By Mr. Léon Calmeau.
" Applications de la vapeur surchauffée." By Mr. Charles Compère.
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" Emploi de la surchauffe dans les locomotives des chemins de fer de l'État Belge." By Mr. J. B. Flamme.
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" Note sur le développement des turbines à vapeur et spécialement sur leur application à la propulsion des navires." By Mr. G. Hart.
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" Production et emploi de la vapeur surchauffée dans les locomobiles: les locomobiles à vapeur surchauffée de R. Wolf." By Mr. Karl Heilmann.
" Sur les turbines-pompes centrifuges à haute pression et à grande vitesse." By Mr. Wilhelm Hoffstedt.
" L'évolution de la construction des grands moteurs à gaz en Belgique." By Mr. Herman Hubert.
" Sur la théorie des moteurs thermiques." By Mr. Jacques Ch. E. Jouguet.
" Sur les volants élastiques." By Mr. L. Lecornu.
" Influence de l'action de paroi sur le rendement des moteurs à gaz." By Mr. L. Letombe.
" Distribution de l'énergie par l'électricité: moteurs collectifs et moteurs individuels." By Mr. Gustave L'Hoest.
" Sur les machines frigorifiques." By Mr. Lucien Marchis,

"Mode de réglage, cycles et construction des moteurs à combustion interne." By Mr. R. E. Mathot.

"Note sur la construction des turbines à vapeur et leurs résultats industriels." By Mr. R. Mouchot.

"La vapeur d'eau surchauffée et son application aux machines à piston." By Mr. Hector Pouleur.

"Considérations sur les turbines à vapeur à chutes de vitesse." By Mr. Auguste Rateau.

"Pompes centrifuges pour hautes pressions mues par turbines à vapeur." By Mr. Auguste Rateau.

"La surchauffe appliquée à la machine à vapeur d'eau." By Mr. Francesco Sinigaglia.

"Turbines à vapeur de Laval à disque unique et de Laval-Breguet à disques multiples." By Mr. Kasimir Sosnowski.

"Note sur l'emploi de la vapeur surchauffée." By Mr. Paul Weiss.

"Les meilleurs gaz pauvres." By Mr. Aimé Witz.

IV.—Section de Géologie appliquée.

"Quelques considérations relatives aux minerais et aux dépôts sédimentaires de Galway, Connaught." By Mr. Richard J. Anderson.

"Les échanges d'eau entre le sol et l'atmosphère — La circulation de l'eau dans le sol: exposé de nos connaissances actuelles et des recherches à entreprendre." By Mr. René d'Andrimont.

"Observations sur le bassin houiller du nord de la France." By Mr. Charles Barrois.

"Ce que les coupes minces des charbons de terre nous ont appris sur leurs modes de formation." By Mr. Charles Eugène Bertrand.

"Les failles de charriage." By Mr. Ludovic Breton.

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"Société Nouvelle de Charbonnages des Bouches-du-Rhône — bassin lignitifère de Fuveau: terrains traversés par la galerie de la mer." By Mr. Henri Domage.

"La houille blanche, ses affinités physiologiques." By Mr. L. A. Fabre.

"Conditions de gisement de la houille en Campine, dans le Limbourg néerlandais et dans la région allemande avoisinante." By Mr. Henri Forir.

"Esquisse paléontologique du bassin houiller de Liége." By Mr. Paul Fourmarier.

"La limite méridionale du bassin houiller de Liége. By Mr. Paul Fourmarier.

"Essai de comparaison entre les pluies et les niveaux de certaines nappes aquifères du nord de la France." By Mr. Jules Gosselet.

"Sur l'organisation des observations géothermiques." By Mr. Léonard Jaczewski.

"Sur le régime des eaux souterraines dans les dépôts quaternaires et tertiaires de l'Allemagne du nord." By Dr. K. Keilhack.

"Le nouveau bassin houiller de la Lorraine française." By Mr. Francis Laur.

"Les bauxites dans le monde." By Mr. Francis Laur.

"Notice sur la constitution du bassin houiller de Liége." By Mr. Octave Ledouble.

"Formation et recherche des combustibles fossiles." By Mr. Léonce Lemière.

"Étude génésique des gisements miniers des bords de la Meuse et de l'est de la province de Liége." By Mr. Georges Lespineux.

"Expériences relatives à la situation géologique des gisements de pétrole." By Mr. Max Lohest.

"Considérations sur la constitution géologique du district minier d'Iglesias, Sardaigne." By Mr. Giovanni Merlo.

"Formation de la houille et des roches analogues y compris les pétroles." By Dr. H. Potonié.

"Sédimentaire ou epigénétique? contribution à la connaissance des gîtes métallifères des Alpes orientales." By Dr. Karl A. Redlich.

"De l'emploi de la paléontologie en géologie appliquée." By Mr. Armand Renier.

"La continuation du gisement carbonifère sur le territoire de la Lorraine et de la France." By Mr. Bruno Schulz-Briesen.

"État actuel de nos connaissances sur la structure du bassin houiller de Charleroi et, notamment, du lambeau de poussée de la Tombe." By Mr. Joseph Smeysters.

"Le gisement de cinabre du Monte Amiata." By Mr. Vincenzo Spirek.

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"Note sur les recherches effectuées en Meurthe-et-Moselle pour retrouver le prolongement du bassin houiller de Sarrebrück en territoire français." By Mr. François Villain.

The next International Mining Congress will be held at Düsseldorf in 1910.

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EXPLANATIONS.

The — at the beginning of a line denotes the repetition of a word; and in the case of Names, it includes both the Christian Name and the Surname; or, in the case of the name of any Firm, Association or Institution, the full name of such Firm, etc.

Discussions are printed in *italics*.

The following contractions are used:—

M.—Midland Institute of Mining, Civil and Mechanical Engineers.

M.C.—The Midland Counties Institution of Engineers.

M.G.—Manchester Geological and Mining Society.

S.—The Mining Institute of Scotland.

N.E.—The North of England Institute of Mining and Mechanical Engineers.

N.S.—North Staffordshire Institute of Mining and Mechanical Engineers.

S.S.—The South Staffordshire and East Worcestershire Institute of Mining Engineers.

A.

B.

C.

D.

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W.

THE INSTITUTION OF MINING ENGINEERS.

SUBJECTS FOR PAPERS.

The Council of The Institution of Mining Engineers invite original communications on the subjects in the following list, together with other questions of interest to mining and metallurgical engineers.

Assaying.
Boiler explosions.
Bore-holes and prospecting.
Boring against water and gases.
Brickmaking by machinery.
Brine-pumping.
Canals, inland navigation, and the canalization of rivers.
Coal-getting by machinery.
Coal-washing machinery.
Coke manufacture and recovery of bye-products.
Colliery leases, and limited liability companies.
Compound winding-engines.
Compressed-air as a motive-power.
Corrosive action of mine-water on pumps, etc.
Descriptions of coal-fields.
Diamond-mining.
Distillation of oil-shales.
Drift and placer-mining.
Duration of coal-fields of the world.
Electric mining lamps.
Electricity and its applications in mines.
Electro-metallurgy of copper, etc.
Engine-counters and speed-recorders.
Explosions in mines.
Explosives used in mines.
Faults and veins.
Fuels and fluxes.
Gas-producers, and gaseous fuel and illuminants.
Gas, oil and petroleum engines.
Geology and mineralogy.
Gold-recovery plant and processes.
Graphite: its mining and treatment.
Haulage in mines.
Industrial assurance.
Inspection of mines.
Laws of mining and other concessions.
Lead-smelting.
Light railways.
Lubricating value of grease and oils.
Lubrication of trams and tubs.
Maintenance of canals in mining districts.
Manufacture of fuel-briquettes.
Mechanical preparation of ores and minerals.
Mechanical ventilation of mines, and efficiency of the various classes of ventilators.
Metallurgy of gold, silver, iron, copper, lead, etc.
Mining and uses of arsenic, asbestos, bauxite, mercury, etc.
Natural gas, conveyance and uses.
Occurrence of mineral ores, etc.
Ore-sampling machines.
Petroleum-deposits.
Preservation of timber.
Prevention of over-winding.
Pumping machinery.
Pyrometers and their application.
Quarries and methods of quarrying.
Rock-drills.
Safety-lamps.
Salt-mining, etc.
Screening, sorting and cleaning of coal.
Shipping and discharge of coal-cargoes.
Sinking, coffering and tubbing of shafts.
Sleepers of cast-iron, steel and wood.
Spontaneous ignition of coal and coal-seams.
Stamp-milling.
Steam-condensation arrangements.
Steam-power plants.
Submarine coal-mining.
Subsidences caused by mining-operations.
Surface-arrangements at mines.
Surveying.
Tin-mining.
Transport on roads.
Tunnelling, methods and appliances.
Utilization of dust and refuse coal.
Utilization of sulphureous gases resulting from metallurgical processes.
Ventilation of coal-cargoes.
Water as a motive-power in mines.
Water-tube boilers.
Watering coal-dust.
Water-incrustations in boilers, pumps, etc.
Winding arrangements at mines.
Winning and working of mines at great depths.

For selected papers, the Council may award prizes. In making awards, no distinction is made between communications received from members of the Institution or others.

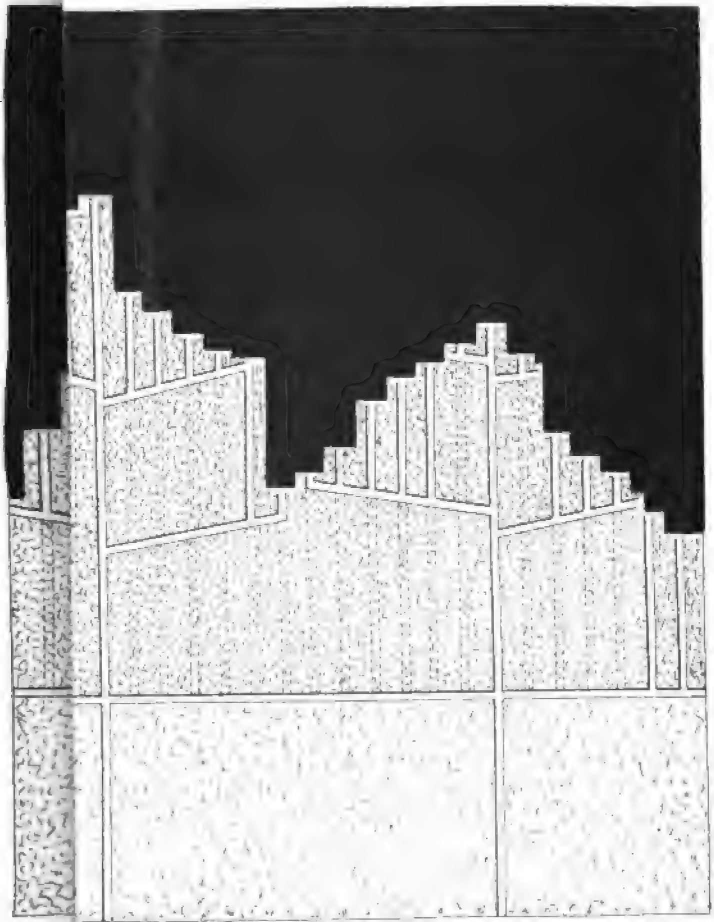


Fig.

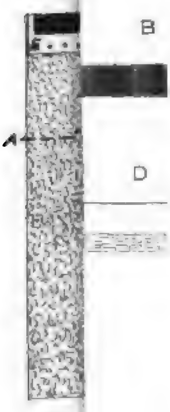
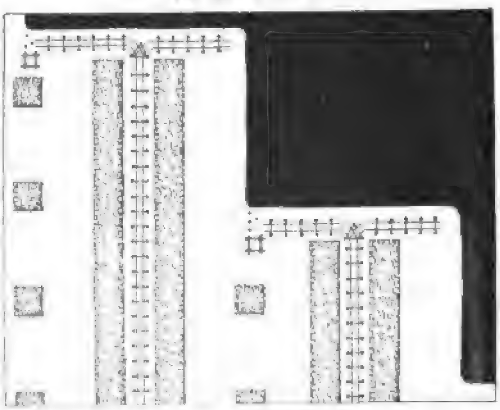


Fig. 6.—Plan of Gateways in a Seam, 7 Feet Thick.



Scale, 50 Feet to 1 Inch.